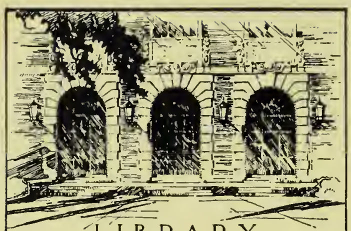

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(From a Photograph by Mrs. R. Lachlan)

Mr. Percival Spencer The Rev. J. M. Bacon Dr. Lachlan

ASCENT FROM THE CRYSTAL PALACE

BY LAND AND SKY

BY THE REV.

JOHN M. BACON, M.A., F.R.A.S.

WITH FOUR ILLUSTRATIONS

CHEAP EDITION

LONDON: SIR ISAAC PITMAN & SONS, LTD.
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To

ADMIRAL

THE HON. SIR EDMUND FREMANTLE G.C.B.

IN WHOSE COMPANY I HAVE BEEN PRIVILEGED TO
MAKE MORE THAN ONE EVENTFUL
AERIAL VOYAGE

Aeronautical Engr. 3 May 45 Clark

PREFACE

In the following pages I have made frequent reference to the enterprise and achievements of aeronauts in this country in bygone years, dwelling more particularly on the scientific work accomplished under the partnership of Messrs. Glaisher and Coxwell.

Ere I had become fairly launched in the task I had undertaken, Mr. Coxwell was suddenly called away from us at a ripe old age, and I treasure a long hearty letter of his—one of the very last he ever wrote—in which he recalls the work for which his professional services were required a generation ago.

In those days substantial grants of money were readily given by the Royal Society and the British Association towards scientific ballooning, and results of the highest importance were secured which placed England far in the fore-front of this branch of physical investigation. Thirty years and more have since passed by, during which little in the way of aerial research has been attempted in England, and I regret that it now seems impossible to win the least pecuniary help or even the loan of instruments from any

British Society possessing funds and equipment intended for the advancement of science.

Meanwhile, both in America and on the Continent large sums are annually forthcoming from public sources for the systematic exploration of the air; and thus this country, which needs more than any other the amplest data for the benefit of its meteorological departments, is now in this particular far behind other nations.

It is hoped that the practical work which is treated of in this little volume and which, whether by land or sky, has often been carried out by private aid, may serve to stimulate an interest among individuals and the public generally in a fascinating and all-important scientific pursuit.

My thanks are specially due for the very generous assistance rendered me by the management of the *Times*, the *Daily Chronicle* and the *Daily Mail*, as also for the kindly notices so often given in the columns of the London and provincial press.

I am further very greatly indebted for the invaluable personal co-operation of many friends, chief among whom are Dr. R. Lachlan of Cambridge, Mr. J. N. Maskelyne, Mr. Nevil Maskelyne, F.R.A.S., Messrs. C. G. Spencer and Sons, of Holloway, and, not least, the Committee and members of the Newbury Guildhall Club.

JOHN M. BACON.

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CHAPTER I

MY FIRST ASCENT

AMONG my earliest and greatest heroes of real life were the man who first went down the shaft after some colliery accident now forgotten, the sailor who threw the live shell overboard in the Crimean war, and a poacher in our village who by his own showing had had more hair-breadth escapes than ever Mayne Reid himself could invent.

But far before all others came Mr. Holland, the hero of the great Nassau Balloon voyage. How could it be otherwise? Mr. Holland had been at college with my father, and doubtless one of the first tales of adventure I listened to was that of the immortal three who made a night voyage in winter from London to the heart of the German forests by an untried way, and in the face of such risks as man had never before encountered. But ere school days were over England had rung again with the bold aerial exploits of Mr. Coxwell and his illustrious colleague, Mr. Glaisher, of Greenwich Observatory; and this stimulated afresh all my boyish enthusiasm.

Still, balloons never came my way until one long vacation at Cambridge, when I witnessed an ascent from Downing grounds. The enclosure chosen for the inflation was somewhat confined, and the balloon on rising fouled a big elm, and for a moment remained caught high up among the boughs. Then it tore off a large branch entangled in the rigging, through the leaves of which the aeronaut thrust out his head and shoulders and gracefully waved his adieux.

I don't think I ever quite recovered the mental bias that this incident gave me. I dreamed of balloons in happy nightmares for long days to come, and whenever I allowed myself to speculate on some possible excursion which should be out of the common, somehow the idea of a balloon would always intrude itself. Shortly before, a school-mate had met with a shocking death, the circumstances of which are known to all the world. Lord F. Douglas had gone Alpine climbing, and was one of the heroic party that first succeeded in winning their way to the actual summit of the "peerless Matterhorn." On commencing the descent, an hour later, the party, consisting of eight, were lashed together, and Mr. Whymper relates in thrilling language how, a slip occurring, the four leaders, including Douglas, were dragged off their legs, and immediately afterwards, the rope having parted, disappeared one by one and fell from precipice to precipice on to the Matterhorn glacier below. Three of the bodies were found the next morning lying together, but not that of Lord Douglas. And so it was supposed that my old school friend lay caught on some shelf of that terrific slope where his body could never be recovered. The thought was terribly distressing to me, and for long the idea haunted me that a balloon might be used to explore the steep which no human eye could otherwise reach.

But years passed, and ballooning in this country was dropping to a low ebb, seldom rising above a mere exhibition at a gala gathering. Every now and then a sensation was caused by some bolder or more tragic incident, as when Captain Burnaby—a mere tyro at the art—crossed the Channel alone in 1882, or when Mr. Powell was carried out to sea and never heard of more, his companions losing their hold of the car just as they reached the water's edge. But scarcely anywhere was an ascent heard of except in connection with gate money, and so much a head for passengers.

One summer, however, at the end of the eighties—two or three years unhappily after Mr. Coxwell had retired from the skies—the old fever returned upon me, and with sufficient excuse. I had been overworked and worried, and as the time for holiday was not yet, I sought some exhilarating exercise that should stimulate body and mind. The Fates somehow, as I think, arrange these things, and, lucky chance being on my side, I came in contact with Captain Dale, an old pupil of Mr. Coxwell's, and one who caught eagerly at any excuse for an aerial voyage worthy of the name.

A light air had been blowing persistently from the south, and the August full moon was at hand. My proposal then was that, with one or two chosen spirits, we should avail ourselves of an ascent which was about to be made at the Crystal Palace; and leaving the grounds at the advertised hour of 5 P.M., should remain aloft as long as possible, and travel through the night under the full moon until checked by mere lack of ballast or proximity to the sea.

No doubt certain days stand out pre-eminently in the lives of each one of us, even when left long years behind—the day perhaps that you made your big score at school, or the day you won your scholarship. With some it may be their first run with the Pytchley or the first tiger hunt that will mark days in which every incident has been branded on the memory. With myself, I think no day stands out in clearer relief than that of my first balloon ascent. Everything conspired to bring this about. The forenoon was gloriously fine. The wind, though somewhat strong, was still from the right direction. Our balloon was a magnificent craft of 80,000 cubic feet capacity, and the skipper himself was as joyous as a schoolboy. Though he could count his voyages by the hundred, he was full of enthusiasm over the venture in hand, not only because it was to be out of the common run, but because it promised the rare treat of a flight over the heart of London in clear bright weather.

During the afternoon the wind manifestly increased and came up from the S.S.E. in blustering gusts. It was the same also higher aloft, as we could see by the straggling clouds which were beginning to race across the sky. And it was clear that if we once got well away we should make the pace. Towards 5 P.M. the crowd was growing big round the shapely monster already struggling restively with the men who, not without occasional difficulties, kept her in check. A balloon of large dimensions becomes a demon of terrific power when restrained in a strong wind, and I can safely say that I have since known many a balloon trip abandoned by reason of risk in far less stormy weather; but we all meant business that day, and soon our party got themselves together. Besides our captain two other experts were to be passengers, and these for the present actively aided in the final arrangements, while I and an old friend, who was to make the venture with me, were told to care for ourselves, and, getting into the car as best we could between the ropes, to lie down out of reach of the tangled straining gear. Then there was a brief but busy time, during which the balloon was "weighed" and made ready; but of all this difficult handling my companion and myself could form little idea, save from the emphatic exclamations of the men who were toiling without. They knew their work well, however, for advertised ascents were seldom abandoned in those days, and so it followed that in two or three minutes our three aeronauts were able to join us in the car, and we got smartly away.

I have dwelt at some length on the preliminaries of our start on this occasion because they were typical of every balloon ascent, only "somewhat more so" by reason of rough weather. It was but a few months after that my good friend, Captain Dale, met his death in an attempt to make an ascent in calm weather from the self-same spot. He must have trusted himself to a balloon utterly unfit for service, for ere it had risen many hundred feet the silk developed a rent, which quickly extended itself from top to bottom, allowing the whole volume of gas to escape. In this awful predicament my friend did all that mortal man could do, casting everything out of the car, even to his own coat, and so far with success that two of the passengers, though terribly shaken, escaped with their lives. Captain Dale himself, however, and another passenger—one of the above-mentioned aeronauts in my own first ascent—were killed on the spot. On calmly considering this fearful accident, experts are of opinion that fatal disaster might have been avoided had the lower portion of the balloon been allowed to form itself naturally into a parachute; but be this as it may, the sudden and unexpected nature of the accident must free Captain Dale from any serious blame in the matter.

Returning to my own experiences in my first ascent, to which I have introduced my readers, I may frankly own that, as soon as our balloon was free, the rough shaking and bumping on hard ground being over, all idea of insecurity vanished. Houses and gardens glided away from us, sloping downwards and backwards into the rapidly deepening abyss; but our little party were left in a separate world of our own, self-contained and seemingly secure by reason of our apparent immobility. However the shifting scene below might shape itself in ever changing perspective, we at least were motionless. Such was the first impression made by the novel experience in my own case. But much more has to be added. If the mountaineer feels an exhilaration as he mounts into higher air, so did we. If the vast clear view of earth from Skiddaw or Snowdon is soul-stirring, so was it now with us. Only the effect was incomparably more striking. To the mountain climber the scene changes but gradually as he mounts by slow degrees, while to ourselves the same transition was brought about in less than twenty minutes' space.

Ere this interval had elapsed the Crystal Palace grounds had receded from view, and though fields and open spaces largely made up the face of earth below us, the boundless stretch of London lay before us rapidly approaching. London everywhere into the extreme distance as far as the eye could reach. To the right the Thames, a little slender stream, its waters apparently pure as silver and running between the fairest banks, threaded its way to the open sea; on the left Wimbledon, and Richmond Park in the far distance. Presently we sailed directly over Kennington Oval, where a cricket match was in progress, but the game was very obviously stopped for a few minutes while we passed, the whole field sending us up a ringing cheer.

Then the roar of the City gathered on our ear, a strange jangle, indistinct at first, but swelling into a hard harsh rattle, weird and indescribable. Not a trace of haze or smoke to all appearance hung over the whole vast town. Streets and rows of housetops all grey, but traced out with the utmost sharpness, contrasted strongly with the parks, and many a smaller patch of green. While all was as familiar as the map of London itself, what surprised one was the large proportion that open spaces bore to the actual mass of bricks and mortar. A moment's reflection will show that this arises from the fact that to passers in the streets the rows of houses always hide the gardens and clearances in between, all of which, however, are broadly displayed in a bird's-eye view.

It was not till we had left the unlovely roofs of St. Pancras and King's Cross behind, and were flying over verdant Hertfordshire, that we saw how the character of the view was changing. It was still broad daylight, but bright contrasts had disappeared and the country everywhere was growing dull and grey. The huge mass of silk above us mainly hid the sky from sight, but the clouds on the horizon were piling up black on all sides. Then, as we passed high over woods, a musical sighing reached our ears, a sound little loved by the aeronaut, for it tells him that the trees are tossing wildly with a strong wind below, and that there will be rough landing. It was already dawning upon us that our voyage would be curtailed. The summer had been one of the stormiest, and whenever rain had fallen it had fallen in earnest. Very shortly we heard it descending in torrents on the distended silk above.

To have proceeded further with our venture on such a night as we were threatened with would have been sheer folly. As to this all were agreed, and the only wise course was to descend while yet there was daylight, and the opportunity of seeking aid and shelter. The disappointment caused by the hasty termination of this my first aerial trip was to some extent compensated for by the masterly display of skill now demanded of our skipper in the descent that was to follow. The rough squalls coming up with the rain storm would necessarily be a formidable element to deal with in the case of a balloon offering so large a surface to the wind as did ours; but a yet more serious difficulty lay in the nature of the country in which we might land. This was thickly timbered, and the fields, generally small in area, were for the most part hedged in with full-grown forest trees.

I believe our captain keenly enjoyed the special service now required of him. To each of us passengers he gave some simple duty with which to occupy ourselves, and, cautiously descending till just out of reach of the tree tops, he waited his opportunity. Certainly the fields rushed past us at a speed I have not witnessed again in any subsequent voyage, but the final landing was chosen with a prompt cool judgment approaching to instinct. Diving over a big elm we plumped into a small meadow only some hundred yards long; but the spot was well chosen. The deep pasture gave the anchor good hold, while the field itself lay sheltered and sloping up hill. The balloon came to earth necessarily with considerable violence, rising and descending again and again until crippled by loss of gas. I have never, however, witnessed a descent more deftly or more scientifically carried out.

The descent took place on a home farm of Lord Salisbury's, just outside the Park enclosure of Hatfield House.

CHAPTER II

BALLOONING IN THE PAST

If my dreams and aspirations had been realised they were by no means satisfied. On the contrary, the exhilarating experience I had enjoyed inspired a desire to inquire into all that I could learn bearing on the new subject presented to me, including the past history and science of aeronautics. Such history, as I soon discovered, begins far back. Possibly man in all ages has conceived the idea of human flight, and amid much that is mythical there remains enough of reliable evidence to show that methods of aerostation were conceived hundreds of years ago, and sometimes carried out with no uncertain promise of ultimate success.

In the latter half of the seventeenth century the Jesuit Father Lana won for himself a place in history by the ingenious and plausible suggestion, that an aerial boat could be launched and navigated if provided with lifting power by large and thin copper balls exhausted of air; arguing that, as a bubble rises in water so would his empty spheres rise in air. Whatever credit may be due to this theoriser, however, he was clearly behind the Franciscan friar, Roger Bacon, who no less than four hundred years earlier conceived the same idea, but with greater clear-sightedness. The "admirable Doctor," as he was called, pictured to himself a limit or upper surface to our atmosphere at no great height above the earth, and insisted that a hollow globe would float thereon. But he seems to have foreseen—what Lana distinctly did not—that the hollow vessel would collapse if not filled with *something*, and so he invented for that something a hypothetical fluid to be termed "ethereal air." We may see here very distinctly the germ of the future balloon.

The method of flight by mechanical means naturally had early advocates, one of the most successful of whom was Besnier, a locksmith of Sable, who, two hundred years ago, came near to accomplishing a very creditable imitation of flight by apparatus of the simplest. On each of his shoulders he laid a light oar, having a large cup-like blade at either end. These oars, being grasped by each hand in front and connected with the corresponding foot by straps behind, were worked alternately up and down, and the hollow of the blades being always towards the ground, it is clear that by thus incessantly beating or flapping the air in a downward direction he counteracted his tendency to fall. Indeed, it would seem that, starting with some little elevation, he was able, by dint of great physical exertion, to raise himself as high as the top of a house.

People, however, did not take up the notion. On the whole, they found it less trouble to get a ladder and go up that way.

It was but some eighty years later, however, that the first great problem in aerostatics was fairly solved, and a very charming little story is here commonly introduced, which may bear once more re-telling. There lived in the year 1782, in Annonay, two brothers Montgolfier, by trade paper makers, and it chanced that one night, sitting over their fire and watching the smoke rising up the chimney, the idea occurred to them that it might be possible to use such smoke as a means of mounting into the air. Acting on this suggestion, they made a large paper bag, and, setting fire to some light fuel in a tin tray, held the bag over it, with the result that the bag soon showed some abortive tendency to rise. While thus engaged, a widow lady, who was a neighbour, entered the room, and, watching the ineffectual efforts of the young men to accomplish their object, recommended them to tie the tin on at the bottom. The old lady was perfectly right in her advice, and it may be truly said that it was the development of her idea that launched the first balloon into space. Larger envelopes constructed of canvas were next tried, and with greater success, and by the summer of the year following a balloon worthy of the name fairly ascended into the sky and dropped again spontaneously a mile away.

This was the commencement of ballooning, which was at once energetically taken up as a new science. For some while, however, no human being ventured up into the forbidden realms now being assailed. True it was that passengers of a certain kind had been dispatched in the newly invented aerial craft, had risen above the clouds, and had come to earth again in safety. Among these a sheep and a duck had been victimised, and on their descent the sheep was found complacently eating the food with which it had been supplied, while his companion was quacking cheerily. Then the spirit of human enterprise asserted itself, and two Frenchmen won for themselves the glory of being the first navigators of the skies. It is questionable if any voyage in the air ever involved more deliberate daring than this the trial trip. Conceive an inflated globe of linen the height of a church tower, nearly as wide as tall, with a gaping mouth of five feet across, and an iron brazier hung below all. Add to this structure an outside wicker gallery encircling the mouth, and you can picture the aerial ship in which M. Pilatre de Rozier and the Marquis d'Arlandes first sailed skyward. The ascent was described as "majestic," but to the voyagers it was far from plain sailing. Standing at opposite sides of the gallery, they fed the furnace with bundles of straw through portholes provided for that purpose, and whenever the balloon caught alight, as it frequently did, they had to extinguish the flames with a wet sponge. The voyage terminated with safety and success after an ascent of 3,000 feet, and a journey of five miles. This famous feat accomplished, the world for a moment stood aghast, and then gave way to an extravagance seldom exceeded. Boundless fresh knowledge they now declared was within man's reach. The bonds of gravitation having been severed, mortals might soar to other worlds. Heaven itself had been taken by storm!

The history of the balloon for the first twenty years following its invention might fill a large volume, nor is that history particularly saddened by disaster. Indeed, we may doubt if a larger proportion of early aerial navigators were sacrificed to science than of those who first learned to sail the sea. And in stating this it must be borne in mind that the type of Montgolfier balloon which continued to be used involved the same element of extraordinary risk already described. In actual fact, fatal accidents, where due caution was observed, were extremely rare, and as proving the remarkable skill and foresight of these early aeronauts, it may be mentioned that a parachute devised a hundred years ago was used again and again with perfect success, and in this respect was far superior to some that were adopted half a century later.

But almost immediately on its introduction, the Montgolfier balloon met with a formidable rival in a much smaller but more efficient balloon, filled with what was at that time described as "inflammable air." This was the name given to what is now called hydrogen gas, the properties of which were first made known by our own countryman, Cavendish. Save for its prohibitive cost, this is still the best possible gas for the inflation of a balloon, and its use soon became general.

As might be expected, the first exponent of ballooning in this country hailed from the Continent, the land of its birth, and it is only in accordance with precedent that he should have been the more enthusiastically received from the fact of his being a foreigner. In all fairness it should be stated that from a letter bearing date 27th August, 1784, and published in the *London Chronicle*, it might appear that the first ascent in Great Britain was made by a Mr. Tytler, who constructed and made use of a Montgolfier balloon at Edinburgh in that year. Be that as it may, however, it is to the young Italian, Vincent Lunardi, that must be assigned the distinction and glory of having electrified London by his superb courage and determination, and of having first taught Englishmen the capabilities of a balloon. His work was all uphill. The cost of inflation by hydrogen was, as already intimated, excessive. Authorities had to be propitiated; subscriptions secured; a suitable ground allotted him. Toilfully he won his way, and the grounds of Chelsea Hospital being at length promised him, definite arrangements were entered upon. Then a French rival appeared, and securing the use of a garden near the Hospital, offered the public a Montgolfier ascent. This ascent, however, becoming a hopeless failure, the mob broke their way into the enclosure, tore down the fencing, and committed havoc in the neighbourhood. Upon this the authorities of Chelsea Hospital withdrew the promise of their premises to Lunardi, who in the face of growing opposition had to seek other open but private space. This at length he met with in the grounds of the Honourable Artillery Company, and due preparations were again resumed, though not without renewed difficulties. At the last hour, unavoidable delay occurring in the inflation, the mob of London would once again have been uncontrollable but for the presence of the Prince of Wales. Rising to the occasion, Lunardi, who was to have taken up a friend, now jumped alone into the car of the half-inflated balloon, which he instantly cut free.

One hundred and fifty thousand onlookers roared their approbation and delight, and the happy young adventurer sailed gaily away—away over Smithfield and the north of London. Thence over South Herts, and as far as South Mimms, where, depositing a cat which he had taken with him, he cast out ballast, and again ascending touched earth a second time at Standon, near Ware. It was not without some difficulty that he here prevailed on the intimidated labourers to assist him, and his troubles were not fairly over till the arrival of some neighbouring gentry.

But from that moment he was the hero of the hour, and shortly learned how great had been the sensation he had created. At an entertainment given him by the Lord Mayor, judges, and sheriffs of London, one of the judges told him how on the afternoon of his ascent a jury was deliberating on the fate of a criminal whom they would have infallibly condemned to death, but learning that he, Lunardi, was in the air, and being unable to leave the court without a decision, promptly acquitted the prisoner to gain their own dismissal and see the sight.

Nor was this all, for in a letter written immediately after the event, he states: "I was flattered by learning that while I hovered over London, his Majesty was in conference with his principal ministers. On being informed that I was passing, the king said, 'We may resume our deliberations on the subject before us at pleasure, but we may never see poor Lunardi again.' The conference broke up, and his Majesty, attended by Mr. Pitt and other great officers of State, viewed me through telescopes while I remained in their horizon."

All this is, more properly speaking, the ancient history of aerostation, to which succeeded a lull, at least in English annals, until we reach what may be regarded as the medieval period, and in many respects the most brilliant of all. It counts not a little to have become intimate with the successors of the immortal Green, to have seen his handwriting, to have actually handled his barometer, and to know the sanctuary where rests in honourable repose the fabric of the veritable Nassau balloon. But when one has been able to appreciate how low the tide had ebbed as regards the practical aspect of ballooning, how little aid the young aeronaut now coming to the front could gather from the experience of his immediate predecessors, the task he attempted, and the triumphs he soon won, we may grant him undisputed right to be recognised as the "Father of aeronautics" in England. It was in the year 1821 that Charles Green first came before the world as the pioneer of the art of ballooning as still practised to-day. So greatly had that art languished, and so low had it sunk in general favour, that previous to the time now to be spoken of announcements of ascents were, from their frequent failure, commonly regarded with incredulity or distrust. In addition to its prohibitive cost, the use of hydrogen gas prepared by the action of dilute sulphuric acid on iron was objectionable, owing to the difficulty experienced in insuring a sufficiently rapid supply. To meet these difficulties, Green conceived the happy idea of substituting carburetted hydrogen, or, in other words, the ordinary household gas as generated at every gasworks.

Convinced of the true value of his conception, he arranged an ascent from the Green Park on the occasion of the Coronation of George IV., which ascent was remarkable, not only from its success, but also for a curious accident connected with the start that is worthy of mention. Overcome by the heat of the day, the exertions required of him, and not least by the crowding of the populace that thronged him, Green shortly before the time of departure begged his friends to let him get in the car, and to allow him to rise a few feet into the air above the heads of the bystanders. This was being done, when by mismanagement the balloon slipped from the hands of the assistants, and sailed away wholly without the knowledge of the occupant of the car, who was at the moment lying down. It was only the shouts of the crowd coming up from far below that informed the aeronaut of the fact that he was free and away.

With his newly found mode of flight, Green soon fairly won his spurs, fulfilling engagements in all parts, at one time making a night ascent from London, at another carrying out a voyage (his sixty-ninth) from Newbury, under circumstances as forbidding as could be conceived. The wind was furious, and storms were blowing up wilder and wilder through the day, so that at the hour of starting, 6 P.M., two tons' weight of iron and a hundred men could scarce restrain his balloon. Yet, as always, he cast off fearlessly, and shortly sailed above storm clouds, from which thunder came in deafening peals. Covering sixty miles in an hour and a half, he rode out his journey till nightfall, and got himself down unscathed.

All that he could attempt so far, however, was but small enterprises in a small balloon; but so great was the confidence he inspired that the proprietors of Vauxhall Gardens now joined him in the undertaking of constructing a balloon of 70,000 cubic feet capacity, and the true magnitude of the venture will be apparent from figures which in these days sound strangely. The cost of entire construction was £2,100; of the silk alone £700, and that of inflation, even with coal gas only, was at the rate of £1 per thousand feet.

No other balloon ever became more famous than this. A few months later, *i.e.*, as soon as its services at Vauxhall Gardens were no longer needed for public exhibition, it was put into requisition for the accomplishment of the most remarkable aerial voyage that in its way the world has ever known. Mr. Holland, of whom I have already made mention, a young gentleman now fresh from Cambridge, determined on an enterprise which, when fairly looked upon to-day must, all things being taken into account, be reckoned to rank with anything of the kind in English history. At Mr. Holland's own direction and expense the balloon was now fitted out for a voyage, of which the direction and distance would be alike unknown, but which should test, as never before, the practicability of navigating the air in face of all chance circumstances and of remaining aloft indefinitely at pleasure.

The aeronaut, of course, was Charles Green himself, while a third voyager was taken into partnership in the person of Mr. Monck Mason, who was to be the chronicler of the adventure. November was already advanced before all was in readiness, the nights were keen as well as long, and the moon was absent. Needful preparations, however, were ample and complete. They took up a ton of ballast, provisions for a fortnight, and passports to every country on the Continent, for none could say within a thousand miles where they were likely to alight.

They cast off at 1.30, and, rising under a moderate wind, began to traverse Kent in a S.E. direction. By 4 p.m. they were over Canterbury, shortly after which hour the tactics of their able pilot began to be called into play. For Green had a firm belief in the existence of definite and steady currents that might be met with at different heights, and as evening closed in, the balloon, which was then flying low, began to drive towards the North Foreland with a suspicious deviation towards the open North Sea. At the same time, light clouds flying high aloft seemed to indicate that upper currents were heading in a direction several points more southerly, and better suited for their purpose. Convinced as to this, Green now ascended to the height he deemed requisite, and by so doing at once righted their course. "Nothing," wrote Mr. Monck Mason, "could exceed the beauty of this manœuvre," which diverted them to a course lying directly over the Straits of the Channel.

In an hour's space they had crossed the sea, and found themselves over the brilliantly lighted town of

Calais; but only for a moment. On they sped across unknown country; over towns and villages with their lights already growing faint and few. The furnace fires round Liège were the last they saw of earth that night, for immediately after they entered a bank of impenetrable fog, and from the fathomless abyss below no further sight or sound broke in upon their long solitude. So the night wore on till the small hours of the morning, when there occurred an incident which, in its way, must have been as appalling as can well be conceived.

It was about 3.30 A.M. The balloon, which, after flying low for some time, had been lightened by a discharge of ballast, was unexpectedly found to have attained an altitude of 12,000 ft. Just at that moment when all around was wrapped in profoundest stillness, directly overhead came the sound as of an explosion, followed by a rustling of the silk, and immediately afterwards the car received a sharp jerk. They held their breath, while the same thing happened a second and a third time, and then all was still. It would seem that for the moment the conviction seized them that in that dreadful region in the dead of night their balloon had burst, and that they must be falling headlong to earth. But these fears, which proved groundless, were presently satisfactorily accounted for in this way. When a balloon is flying near the earth it necessarily somewhat collapses and elongates. This had been the case with their own balloon, and the moisture-laden cords and netting must have frozen round the silk as hard as steel. Then, when presently the balloon rose suddenly to a great height, it would reassume its globular shape, and the stiffened cordage would bend to its new position with a crack and a snap, giving at the same time a jolt to the car and silk.

The historian whom we have already quoted speaks in rapture of the sunrise that at length terminated the long night. As they were alternately rising and sinking the sun to them rose and set several times, "nor was it," says Mr. Monck Mason, "till we had three times made the sun rise and twice beheld it set that we could fairly consider it established above the horizon, and daylight complete." This extremely beautiful phenomenon thus described has, as I shall mention, fallen to my own good fortune to witness with the added glory of a full moon also dipping and rising at the same time in the opposite quarter of the heaven. No sooner had the sun, as yet not risen on the earth, dispersed the shadows of the country below, than the voyagers, whose career we have thus far followed, speculated with much uncertainty as to their whereabouts. The wild trackless prospect, covered here and there with snow, suggested Poland, or the Steppes of Russia, and it was not till they touched earth at 7.30 that they learned that they had landed among the German forests, and decided that the object of their venture had been fairly accomplished.

Sixteen years passed by, and ballooning, save as an amusement, had once again languished in England. Green was still before the public as the most experienced aeronaut of the day. He had made a thousand ascents, and though he had fearlessly faced every danger of his calling, he had come safely out of every difficulty. He was further destined ere his retirement to take part in the revival of true scientific ballooning. It was in the year 1852 that the British Association began seriously to entertain the idea of utilising a balloon as an instrument of scientific research, towards which end they availed themselves of the services of Mr. Welsh, of Kew Observatory, and, granting him due equipment, commissioned him to make a series of observations in specially organised voyages. Mr. Green was to take the helm. All was well planned and executed, and by the middle of autumn four ascents had been made, yielding results of very considerable value, and giving high promise to future research. Unfortunately, Mr. Welsh, falling ill, was unable to continue his investigations.

It chanced, however, that Mr. Welsh's last ascent had been keenly watched—watched from start to finish, with intense interest by an observer as experienced as himself. From the roof of Greenwich Observatory, by means of a good telescope, a spectator had seen the balloon rise from Vauxhall, climb the sky to nearly 23,000 ft., and settle earthwards far down in the E.S.E. near Folkestone.

The onlooker was Mr. James Glaisher.

CHAPTER III

A BALLOON RACE

Mr. Glaisher's classical researches in the heavens have been so widely and so often spoken of, that there will be no need to detail them at any length. It will, perhaps, be better to introduce them in these pages alongside of, and in comparison with, the more recent experiences which, by good fortune, have fallen to my own lot.

It is now five-and-thirty years ago since Mr. Glaisher's voyages of discovery were undertaken, and though knowledge has increased and methods have improved since then, yet so ably were his investigations carried out, and so handsomely was he equipped by liberal grants from the scientific world, that his results have a very special and permanent value. Far more than this, his own simple and conscientious narrative, embellished with his vivid and picturesque descriptions, has a charm for everybody. Nay, the most listless reader casually glancing through the mere illustrations in that tempting volume, "Travels in the Air," irresistibly catches something of the enthusiasm of the writer.

No one can fail to be struck by the simple diagram of the lofty climb, through rain and upper sunshine, fog and snow, or by the unearthly phantom of the balloon shadow depicted riding through the highest cloud. But an interest, intense to the verge of painfulness, is aroused by the sensational but by no means overdrawn illustration of the grave misadventure which befell the author at the estimated height of nearly seven miles. He was in this, as in all other aerial ventures, accompanied by the famous practical aeronaut Mr. Coxwell, then in the heyday of robust manhood.

The exploit was, and ever will be, without a parallel, for in those days there were no cylinders of compressed oxygen, such as are now taken aloft for the refreshment of the traveller fainting from sheer rarity of air. Ascending on a summer's day from Wolverhampton, they reached the first mile high in thirteen minutes, the second mile six minutes later, and in twenty-five minutes from the start were three miles high, and the thermometer had fallen to 18°. Twelve minutes later they were four miles high, and the thermometer recorded only 8°. In forty-seven minutes from the start they were five miles high, and the temperature was below zero. Mr. Coxwell, who was in the ring exerting himself, was panting painfully; Mr. Glaisher, on the contrary, sitting with his elbow on the table which carried his instruments, experienced for a while only some dimness of vision. But presently he found his arm was powerless, a moment later his head fell over on his left shoulder, and after a brief interval he lost consciousness. Mr. Coxwell, desiring to come to his friend's assistance, found that his own hands were also powerless, and that insensibility was stealing over him. With a supreme effort, however, he succeeded in gripping the valve line with his teeth, and in this way brought the balloon down in safety.

To any one gleaning ideas of aerial travel from the illustrations in Mr. Glaisher's charming volume, the question would at once occur—Could photography fulfil, and more faithfully, the work of the artist's pencil? Until lately the answer to this question must have been given in the negative. Up to some half-dozen years ago there were, to the best of my belief, no published photographs worthy of the name taken from a high-flying balloon, and for this there was sufficient reason. Under ordinary circumstances the lower levels of the atmosphere must be considered as containing myriads of particles in suspension which, if a high sun be shining, will have their sunlit surfaces above, while their under-sides remain in shade. Thus to an observer below they appear unilluminated, and so invisible; while to the aeronaut, on the contrary, they throw back a flood of light which commonly gives a haze to the landscape and flares the photographic picture.

It was only by aid of special means, and under chance favourable conditions occurring very occasionally during two exceptional summers, that I myself succeeded in taking photographs good enough to be afterwards deemed worthy to figure in London exhibitions. Half-a-dozen years ago, however, as I have said, I should not have known where to look for such photographs.

It was about that period that I made an ascent under the guidance of Mr. Percival Spencer, accompanied also by my son, in pursuit of further knowledge of things aeronautical, with a view to future more serious work. The voyage, which extended over three hours, proved fruitful in ways unexpected, for we had no instrumental equipment, and the occasion was, ostensibly at any rate, only arranged for purposes of exhibition, being, in fact, simply a balloon race. To begin with, I learned a little, which impressed me much, about the moral effect of ballooning. The rival balloon was in charge of a gentleman aeronaut to whom I was proud to be introduced. He was, indeed, one of the survivors of the party that were in the car with poor Captain Dale when he met with his fatal accident. Will it, then, be a matter for surprise that one to whom ballooning had been a mere pastime instead of a profession, should have pursued a recreation in which he had been severely handled, even to the verge of losing his life?

I will lay stress on the fact that he had turned up unexpectedly, requesting to be allowed to take the helm, simply because his enthusiasm would not allow him to stay away. I learned this from his own lips with sincere and sympathetic satisfaction, but I learned yet more of an instructive and consolatory nature. From his own showing the moments of his terrific fall are impressed on his memory with painful vividness, but he has never had any recollection whatever of actually reaching the earth. Clearly nature may be far kinder to the sufferer than one might be led to suppose, and if it is common that, even in such a severe accident as that of my friend, returning consciousness brings no recollection of suffering, surely we may reasonably hope that many violent deaths, however distressing in their circumstances, are, after all, painless.

But the incidents of the day I am describing taught me yet more about the moral effect of aerial travel. Our rival balloon had two passengers, one of whom in times past had made voyages into cloudland, but a year back he had married, and with proper feeling had yielded to the protestations of his wife, and promised to abandon ballooning, and yet—explain the circumstance as you will—just a twelvemonth had passed, and now the wife and husband were going up together, and, to say truth, both looked extremely happy.

The attempt to make a fair start was an unusual and not altogether easy operation. The two balloons were moored some sixty yards asunder, to guard against their fouling, and everyone who has witnessed the fidgety way in which an inflated balloon behaves when held in check—somewhat resembling an impatient horse kept standing on a cold day—will understand the coaxing and restraining needed to get both craft away together. This, however, was, by the aid of many practised hands, well accomplished, immediately after which, regarded from my own point of view, the relative behaviour of the two balloons became full of interest and instruction.

Our opponent began by forcing the running, and from the first with obvious success. In nautical phrase she was on our port beam, that is on the north side of us, as we led off heading E.N.E. But her tactics were to get above us, and in so doing she not only drew over to the south side of us, but sensibly forged ahead. The reason of which should be obvious when we remember that higher currents as a rule move more rapidly than lower. The lower stratum of air dragging along the earth is necessarily slowed down while the stratum just above it is in turn impeded, though to a less extent, by being in contact with it. Thus the speed of winds commonly increases with altitude. To set, however, against the gain in speed acquired by flying high, there was a material loss entailed by expenditure of ballast, which, in other words, meant so much loss of staying power.

The next move in the game was played simply by lapse of time, without manœuvring, and resulted in a slow and steady rise and consequent gain on our part, while the opponent, reaching the culminating point due to her leap into space, suffered now from the loss of gas incurred, and was presently sinking below us.

It may not be unnecessary here to explain the principle on which a balloon rises or sinks in free and equable air. Leaving out of consideration any disturbing effects of currents or changes of temperature there could be no such thing as a balloon poised in space. Through the open mouth below the gas is always slowly leaking, and causing a gradual fall in altitude, to check which ballast has occasionally to be discharged. But so delicate is the balance of a balloon that the impetus gathered in rising carries it to a point beyond the height which would be its true level, and the pressure of the surrounding air there being less, the imprisoned gas, always seeking to expand and escape, succeeds to some extent in so doing. Exactly in like manner a cork sometimes flies out of a bottle in a balloon that is rising. The expansive power of the air within the bottle finding diminished pressure without, forces the cork outwards. Thus it will be seen that, other conditions not interfering, the motion of a balloon is like that of a pendulum, constantly rising above and then sinking below what would be its true level at any moment, and all the while at the expenditure alternately of sand and gas.

From an early stage of the race I am now describing it was evident that our balloon was the more heavily, in fact too heavily, loaded, by the dead weight of passengers. We had the smaller quantity of sand at disposal, and, in consequence, our defeat was only averted by artifice.

Two hours had passed and we were flying at 3,000 feet a little south of Woolwich and drawing on towards Plumstead. I shall not readily forget a strange sound that then smote on the ear, one instant only and then died, but which was repeated again and again at frequent intervals. It resembled the spasmodic yelp of a dog just underneath the car, though it really came from a mile below. Far down on the marshes artillery practice was in progress, and the resounding boom of the cannon, as heard on the ground, came up to us simply with the effect that I have described. Bearing a close analogy to this phenomenon is that described by Mr. Whymper high up among the Andes, where he noticed flashes of lightning each "followed by a single bang."

Presently we crossed the river just over the point where Rainham Creek runs in, and at this moment we saw our rival still on the south bank and still distancing us. But the river lay between us, likewise much broken ground, and as we began settling down this somewhat masked our movements. To say truth there was little more manœuvring left us, for we had but one bag of ballast remaining, and this we were already paying out by driblets to save collapse.

Down we swooped, fast and faster, in spite of the constant slender flow of sand, till at last we stood ready to meet a seemingly inevitable plunge into a long level pasture. Quickly we discharged the whole remaining ballast and so abode the issue. It was touch and go. Diving to within three feet of the ground our balloon hesitated, halted, and then kept level, while we coasted the whole length of the paddock with cows in stolid wonderment lying right and left of us. Then we righted, the impetus of rapid descent was spent, and we lifted, shooting up once more in right good earnest. Down plunged fields and woodland, into such a fast deepening gulf that the aneroids were promptly consulted, and showed the index hand running backwards without stop or stay till near 6,000 feet was noted and we were still rising. The pace had been great. We were now more than a mile high, and we looked down and around. There, already behind us, lay our opponent sprawling on a grass field, a crowd of people round her, giving us an easy win after all. They had evidently thought us beat and so came down. We were now above the cloud line and the effect surpassed anything that I had seen before. But our limit was reached, and we were once again descending as before, with the difference that now our ballast was all spent. But our aeronaut was equal to the occasion. Choosing his ground he paid out the heavy anchor, and waited for it to strike.

The manœuvre answered perfectly, letting us down in a clover field twelve miles from the sea.

CHAPTER IV

I BEGIN MY EXPERIMENTS

It will be seen that the peculiar exigencies of our voyage had resulted in a somewhat unusual treatment of our balloon, and an important practical fact was learned thereby, which will be illustrated more than once in these pages. This fact is that in any voyage a balloon, as it draws to the end of its life, can be made to take astonishing giant leaps such as in a common way it would be incapable of in the early stages of its career, and this is a matter well worth a little consideration.

Take the case of a balloon just ready to start on its voyage, and so arranged that it is exactly poised close to the surface of the earth. At that time it is carrying its maximum of weight if, as we will suppose, it is quite full of gas. Then say that one bag of ballast is thrown out to allow it to rise, and that—the first duty of the aeronaut—the neck is at once untied to prevent the imprisoned gas from bursting the globe as it reaches rarer regions where, of course, the restraining pressure of outside air would be diminished.

The result of all this is that the balloon will rise up to its true balanced level—a low level this time—and, as I have shown, by gathering impetus will be carried like the swing of the pendulum somewhat beyond previous to sinking again.

In performing this excursion it will necessarily have lost gas, so that when in the inevitable course of things it has settled down near earth again, it will be in a different condition from when it started, for (1) it will be lighter, and (2) the silk globe will have lost a certain amount of gas, and will be no longer completely distended, but a little collapsed. At this point suppose a second bag of sand is thrown out. Now that the balloon is lighter, this represents a relatively larger expenditure of ballast than did the first bag, so that the balloon will this time reach a higher level than before, while at the same time there will be less loss of gas, since there is spare room in the collapsed globe to allow of its expansion.

Thus the second leap into space will be higher and longer than the first, and so on; and thus it comes about that a bag of ballast cast out towards the end of a voyage will often entail a seven-league stride over half a county or possibly an unlooked-for flight out to sea, and the truth of this will be brought home in a subsequent chapter.

But let me speak of other observations; and first with regard to the cows. I have paid considerable attention to the effect that a balloon overhead has upon animal life, and unhesitatingly I affirm that the creature most wildly excited is man. I have seen a farmer, followed by his men, rush madly after a balloon across a field of standing corn, causing reckless damage, and all without the smallest occasion. I have on reaching earth had a man of seventy years come gasping up, his hand pressed hard over his heart, simply because for the life of him he couldn't help running his hardest over the stubbles, though no one wanted him. Dogs appear to be greatly affected, judging from the excited barking that constantly reaches one in a balloon. It would seem that they yelp at a balloon overhead much as they would bay at the moon. Birds are cowed and lie close. Horses take alarm, while sheep will sometimes become so scared that they will bolt through a thick hedge. A jackass will become interested when it has had plenty of time to think the matter well out, but a cow? Oh, no! Whether it feels any astonishment I know not, but it declines to show any. I have described how we brushed close past a herd of them lying resting in the meadow that summer evening, but they simply lay still, ruminating the while as though it were no concern of theirs. It was otherwise, however, with one particular cow, as I must tell.

As we reached our final and highest elevation we were, perhaps, a little sorry that all our ballast was spent, for we then had more than a mile to fall to earth with no check save the anchor. Could nothing be spared to throw out? Well, yes, there were half-a-dozen empty lemonade bottles. They were hard and solid truly, but the fields below looked quite empty, moreover there was a small round patch of bright green, presumably a pond covered with duckweed. It became irresistible that we must try and throw a bottle into it. Throwing at an object a mile away, however, is not easy, and the game grew exciting. Whether we actually hit the pond we couldn't be sure, but one thing was quite clear, namely, that we nearly hit something else. Had it been a man he would certainly have run; this creature, however, only walked away leisurely with imperturbable dignity. I suppose there comes a time when even a cow will not disdain to get out of the way.

A matter already mentioned is considered by most a little hard to understand. It has been explained that in a "right away" ascent, the mouth of a balloon must of necessity be kept open, and as this is a foot or more across it comes as a surprise to most minds that the gas which is so greatly lighter than air does not quickly escape. The law of the "diffusion of gases" needs no insisting on, being one that is self-evident to every ordinary understanding. In actual fact the law is one of great rigour, for it is known that if bottles containing gases of different densities be connected by a tube and held even, so that the heavier gas is below, the two gases will presently invade one another's retreat, and become uniformly mixed. Nay, the same will happen even though the connecting tube be plugged with dry plaster of Paris. And yet the fact remains that during several hours the actual loss of gas through the neck of a balloon due to this same law is so small as to be scarcely appreciable. It will then be clearly understood how it comes about that small injuries to the fabric of a balloon are seldom of serious consequence. Indeed it has been proved that if the silk be pierced by a bullet the ragged edges of the holes, if below the equator, will to a great extent close themselves up again, and the leakage will be inconsiderable.

In the aerial excursion just recorded the most noteworthy physical facts that forced themselves on my observation were, I think, those relating to sound. The short angry bark of a cannon detected far aloft I have already referred to, and probably no sound heard that afternoon smote more forcibly on the ear. But the shriek of a railway whistle seemed also to be carried indefinitely into space, as also the roar of heavy trains when they rumbled over a timbered bridge, the whole structure in this case vibrating like the sound body of some giant instrument. Anon each time as we descended from higher levels the familiar sounds of earth would return in a definite and striking sequence. There were voices of many kinds, the shriller pipes always leading,—the crow of cocks unseen, and indeed invisible from distance, the bark of a dog, next the cries of human beings, but the shouts of children always first. Again, the absence of all echo from sounds below contrasted strangely with the full return of one's own voice off the earth, as we came down to short range.

But in the higher altitudes undoubtedly the most impressive phenomenon was the silence—a silence so profound, so unexampled, it seemed a condition of things that might another day be turned to special account. Now it has of late been brought home that not a few disasters at sea have been occasioned, at least in part, by the unaccountable failure of sound signals. As one example fresh in our memories, we may recall the fate of the *Stella*, which, leaving Southampton on the 29th of March, 1899, bound for the Channel Islands, was wrecked on the Casquets, off Alderney, although there can be no doubt that the warning fog signals were loudly sounding.

Mariners, however, have for some time past had fair warning against the capricious behaviour of sound signals of the character of the syren, or hooter. The warning has come in the shape of reports that appear in their strangeness like mere tales of the sea; and as it chanced that these tales first came over from America they were received by many, if not with grave faces, with grave distrust. A report such as we are referring to would run somewhat thus :—

A fog is lying off the coast with the usual accompaniment of light air and little sea; in other words, there is an absence of any commotion that might interfere with the hearing of a ship's watch who, as the view was obscured, would be keenly awake to any signals of warning or distress. A vessel, say seven miles out, is heading in towards some point on the shore where a light station is known to be, and now for the first time catches the drone of the warning fog-horn ahead. Approaching a mile nearer, however, the sound is lost until another half mile has been covered, when it breaks out again with abnormal intensity. On approaching somewhat nearer the sound, without assignable cause, is again lost, and presently again recovered, the same alternation of sound and silence being perhaps several times repeated. Inquiry has, nevertheless, shown that the fog-horn has all the while been duly and uniformly sounding. Then in some cases the vessels have put out again, and established to their satisfaction that practically the identical phenomena are repeated merely in their reverse order.

The record can only be interpreted on the supposition that in her short run the ship traversed certain regions where sound disappeared, or since it was clearly not arrested, that there were, say, areas or zones of silence where the sound waves, travelling outwards, by some interference or refraction failed, but only to reappear in strength further on.

The attempts that have been made thus far to show that the silent zones remain constant, though

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interesting and suggestive, have been as experiments manifestly faulty. They will require to be repeated sufficiently often after varying intervals of time by night as well as day, and in all possible conditions of atmosphere. Thoroughly scientific experiments throwing some light on the above puzzle were, as must be well known, made by Professor Tyndall thirty-five years ago. In those days the grave danger of mammoth liners trying to beat each other's record and flying at racing speed in almost all weathers was practically unknown; but the need of the most efficient form of sound signal was recognised, and exhaustive trials were carried out by the professor, under the auspices of Trinity House, and repeated under almost all conditions of wind and weather. Special and elaborate apparatus was installed at the South Foreland, where there are cliffs 230 feet high facing an open sea, and almost every conceivable form of warning signal was in turn made to speak alike from the beach and from the heights above, while the observers put out to sea and so manœuvred their vessel as to test the penetration of sound at all distances and in all directions in respect to the wind. Very complex, and at times almost conflicting, results were obtained. Guns would on some days outdistance the more prolonged sounding of a horn. On other days the reverse would seem to be the rule; but on the whole it appeared proved that, while a gunshot might be more penetrating, its instantaneous report was more likely to be missed through momentary inattention. On the other hand, the continuous drone of the hooter or wail of the syren was often attended with very variable and fitful hearing in changeable states of atmosphere.

But one of the most startling phenomena which Professor Tyndall thought he had established was the occasional presence of *aerial echoes*, *i.e.*, echoes simply flung back from the seemingly empty air. To interpret these phenomena it was necessary to conceive obstacles of the nature of opposing masses of air, all unseen, yet of a different density from that surrounding the observer; and granting these occasional opposing masses, it became easy to make them accountable for any capricious obstruction to the outward travel of sound. There were, however, other conclusions arrived at in the South Foreland experiments which claimed attention, such as that fog, contrary to the experience of former authorities, had no influence on the passage of sound; and again the astonishing assertion of a French savant seems to have been passively accepted to the effect that sounds are heard best not down the wind, but across the wind.

Deeply engrossed by the whole of this painstaking and fascinating inquiry, I found my own interest culminated in one frank admission that was in the end made by Professor Tyndall himself. That indefatigable scientist entertained a strong desire to test his results from a free balloon, but owned that, on consideration, the risk appeared too great. To myself, however, the idea offered the greatest attraction, and was in entire accord with my own conclusions. Unquestionably, the car of a free balloon was an ideal observatory for investigation of sound. To begin with, the observer is carried away into regions of absolute silence, and not only silence, but relative stillness. It can never be thus on any earthly station. Even in a specially equipped vessel, whether travelling or lying out at sea, there is never the same quietude. The movement or management of the vessel; the lap of the water against the sides; the wind in the rigging, are all, more or less, distracting elements when the ear is intently listening. It is the same also on land. Take the case of a quiet open common on a peaceful summer night. To the casual visitor it might appear that there was an absence of all sound until he is called upon to be an observant listener; and then, indeed, the air is found to be full of sound; faint, truly, and hard to trace, and yet a perfect turmoil. The blending of far sounds coming in from all distances; the hum of insect life; and the rustle of the night wind blowing in fitful gusts through herbage.

It is utterly, most strikingly different, with the observer sailing through the skies in an unrestrained balloon. To him, even though the wind be blowing stiffly, there is no consciousness of motion. His craft travels with the current, and, for the most part, no breath even fans his cheek. Then there is naught but the depth of space around him, without the slightest obstacle to cause disturbance or reverberation. The one exception to this being the globe above him which, with its open mouth leading up into the large symmetrical cavern directly overhead, supplies only a true sounding board. Over and above all, it is at once clear that any prearranged sound emitted from the starting place must travel directly down the wind.

Meeting with the invaluable co-operation of two unrivalled scientific mechanicians in the Messrs. Maskelyne, of the Egyptian Hall, a series of preliminary trials were carried out with a view of testing the best form of transmitting and receiving instruments to use in more crucial experiments, and it will suffice to say that the sounds agreed on to be tested ranged from faint-whispered and sibilant sounds to articulate speech, and to shouts of words of command. Then, as distance increased, horns of various kinds were introduced, singly and in combination, in unison and in discord. Steam power working the hooter and syren was next called in aid. Contrasted with the penetration of these sounds was tried that of various reports, the ping of the rifle, singly, in volley, and in rapid sequence. Finally, the heavy fire of cannon, and the more startling rattle of the service gun-cotton fog signals.

Then a field day was organised, and a private balloon voyage was arranged at Newbury, when in the heavy air of a sultry July evening an ascent was made, and continued during two hours, the balloon flying level, low and leisurely, and settling earthwards at sundown ten miles away.

As in all such initial trials, the results were instructive rather than conclusive. It was satisfactorily proved that we were in possession of a sound-gathering instrument of great efficiency. This had been the outcome of much trial, and was in effect a giant ear designed to gather in sound waves very much as the mirror of a reflecting telescope gathers to a true focus rays of light; and further, it had this resemblance to the telescope, that the direction of distant sound could be accurately located.

CHAPTER V

SOME ACOUSTIC MYSTERIES

As the outcome of our trial trip just recounted, it was clear that our instruments would serve well for future work. It was clear also that the scope of much future work was already indicated, while at the same time the majority of our present observations would need repetition. But there was one result met with that suggested a somewhat new and fascinating line of investigation. There had been other preparations, besides those already mentioned, made for the carrying out of special acoustical experiments. By kind co-operation of the military authorities, arrangements had been made for the firing of heavy cannon at Southsea, forty miles away, during the progress of our voyage. Moreover, at the moment of our ascent the heavy tenor bell of Thatcham church tower, three miles to windward, was started ringing continuously for half an hour. It was this last item in our programme that opened up an interesting and valuable inquiry; for the account that the big church bell gave of itself was not at all what was expected of it. Its resonance from our lofty station was infinitely more feeble than might have been supposed; and yet the tower from which the giant voice was speaking had a latticed window facing our way freely open to the sky, and, moreover, our own course continued due to leeward. Was there any precedent for this remarkable negative result?

The answer to this question had been given near the same observing ground a hundred years before. Away across the Down, not a dozen miles from the place of our descent, a belated traveller making the long lone journey from Swindon to Lambourn one winter night, had been overtaken by a snow storm, and, wandering from the track, became hopelessly lost in the wild white waste around him. The nature of the open downs in that neighbourhood is such that no landmarks offer themselves as beacons, and there are practically no homesteads, nor even the bare shelter of a barn for many miles. Under these circumstances the case of a wayfarer without guidance and assailed by a blinding storm was altogether hopeless. The unhappy man toiled on for a while with the energy of despair, but presently the unequal struggle was fought out; strength was exhausted, and in some deeper hollow, yielding to his fate, he sank down to die. It was just then, however, that the sound of a distant church bell smote on his ear, and with hope revived he was able to direct his steps to some haven of safety.

This story, of course, has many a parallel, and the point to be brought out is the apparent fact that the intermittent sound, faint through distance, was imperceptible when borne freely across the open, but gathered intensity when caught in the bay of some hollow ground. Exactly in like manner a warning bell at sea is often unheard on the top of a cliff, but heard distinctly on the beach below where the hollow of a rock may form a natural receiver.

We may now be prepared for a statement which has reached me, and which is vouched for by a turret clock manufacturer of large experience, viz., that the striking of tower clocks will be heard and again unheard at different points across open country with a capriciousness equalling that of the sea-signals already spoken of.

During a few weeks of every year I have admirable opportunity of observing the behaviour of church bells from my own house, which, standing nearly 500 feet above sea level, is within earshot of four principal ringing steeples from three to four miles distant. Two lie below in the broad open valley of the Kennet, to S. and S.W. respectively. Two others are each behind a shoulder of higher ground, one due W., the other to the N.E., and in the few weeks preceding Christmas it is customary to hear constant steeple practice from these different quarters in the quiet hours of a winter's night. Repeated observations have proved very instructive. When a N.E. wind is blowing, and only then, can the ringing from the tower in that direction be heard, but then it is borne over the intervening brow with a clearness and steadiness that is sufficiently remarkable. From the opposite quarter, the bells away in the west, being of lighter calibre, are heard with greater difficulty over the opposing hill; a west wind, however, if not too boisterous, will carry the sound, and if there be a northerly component in it the sound commonly grows crisper. A fine peal of six to the south, those of Thatcham already mentioned, can be always heard with a north wind as if five or six miles distant, but with a south moist wind, almost as if at the verge of my own grounds. Yet it is out of the south-west that we get the most noteworthy and instructive message. This comes from the tower of Newbury church, which contains a heavy peal of eight bells, ringing in leisurely to the swing of a tenor of upwards of a ton. Thus there is abundant interval in which to catch the stroke of each individual bell, if acoustic conditions are favourable. When the sound comes down the wind even the treble bell may be heard, but the chief peculiarity under these circumstances is that characteristic "rise and fall" which adds such a special charm to distant ringing borne across open country. The true cause of this is unquestionably the unequal nature of the atmosphere generally prevailing when the wind sets from the stormy quarter. Everyone is familiar with the broken character of the cloudy sky when showers blow up in visible gusts of moisture-laden air. But when wet winds are blowing, even though their nature be not made patent to the eye, they are commonly composed of volumes of air of different degrees of humidity hurrying on in detached masses. This is undoubtedly a principal cause of the unsteadiness of the hearing.

I shall have to tell in due course of observations which I had the privilege of making in changeful weather on a lighthouse out at sea. When days were fair and atmosphere settled, both seeing and hearing would be characterised as "steady," but on the advent of broken weather, if a seaman's glass were fixed on a distant mast and eye and ear were both attentive, not only would the warning sounds of bell or syren from distant points "rise and fall," but the mast would flash in and out of sight in a corresponding fitful manner. Here was almost ocular proof of the cause of the rise and fall of the bells I have been speaking of. The aeronaut equipped with proper instruments is able to testify to the way in which the atmosphere is frequently *mottled* as it were with volumes of air at different densities, as I shall show in proper place.

I have heard bells under many different conditions when sailing far overhead, sometimes during mid-night voyages when the sound of turret clocks will speak out with great distinctness in the silence of night hours, but my memoranda point to two facts: (1) that they have only been heard when they were almost directly below, and (2) that, as can now be readily explained, the sound has been uniform without any approach to "rise and fall." The chief moisture in the air lies only in a shallow layer near the earth, and consequently to an observer directly overhead sound cannot come through any considerable depth of the mottled air described above.

It need hardly perhaps be pointed out that a simple rhythmical alternate rise and fall of a single bell may be due to the fact that when in full swing its open mouth turns two opposite ways, and the sound is in a sense, flung to the winds in different directions. The ear, too, is doubtless quick to catch this pleasing effect. Hence the deep impressiveness of a muffled peal. The "Dead March," as played by a fine military band or on a cathedral organ, may be counted the most solemn and soul-stirring requiem, and yet I would question if it be so solemnly impressive as a muffled peal properly executed on a fine ring of bells.

Such a peal used to be rung with rare effect on very special occasions on the beautiful twelve bells of St. Mary's, Cambridge, and two such special occasions occurred during my freshman's year, namely the death of Whewell and the death of Lord Palmerston. The rule in vogue was first to ring a brief peal with both sides of the clappers muffled. This terminated abruptly with the bells *upset*, when the muffling of one side of each clapper was removed, and the ringing recommenced, this time in true muffled peal. First all the twelve bells speaking freely were answered immediately by the ghosts of their own selves—by that indescribable far-off sound, weird and solemn, seemingly coming out of another world. Irresistibly the listener would pause and count out the twelve strokes, alternately full and hushed; and presently he counts but eleven, the treble bell apparently missing, and before he has well assured himself of this, the next in order is silent too, and now but ten are speaking in the place of twelve. So one by one the higher bells in order drop out, while those of heavier metal strike on, but more leisurely, widening out their intervals so as to count out with equal strokes the invariable length of each bar of the solemn music as marked by the stately swing of the great tenor, and in this impressive manner each bell in dying out leaves the survivors filling the gap with more and more measured utterance. Presently but two are speaking, answering one another with long resounding beats. Finally the great tenor swings on a few strokes alone, its deep funereal muffled voice ending the long-drawn cadence.

Before dismissing the subject of bells, I may call attention to the mellowness imparted by distance to their sound, which is rather that of a harsh and jangling clangour when heard at close quarters. Discordant elements in the vibrating metal are blended in harmony when heard at greater range. It was thus in the experiments mentioned in the last chapter. The horns that were blown together, slightly out of tune, seemed to lose their discordance more and more as our balloon drifted further into distance.

But returning to the starting point of our aerial investigations. Were we any nearer to interpreting the unaccountable failure of warning sound signals at sea? If a powerful sound wave travelling laterally over level ocean failed to betray itself at any particular region, then one of two things was likely to have happened: either the wave may have been refracted or bent up and over the region of silence, in which case the aeronaut was of all others the observer to discover its cause and course; or again, the wave may have been in part stopped, in which case it should be reflected in some direction, or, in other words, there should be something of the nature of an *echo* heard somewhere.

Readers will at once connect this idea with that charming, almost poetical conception of Professor Tyndall's, that echoes may at times be heard out of the empty air. Among all the quests now presented to myself and my scientific colleagues, none was more fascinating than this. I felt like Franklin when commissioned to go and discover the North-West Passage. My work was to be that of a true explorer. I was to sail the skies, to penetrate their every recess, and entice these coy aerial echoes from their hiding.

Summer days and sufficient leisure were at my command, and a series of well organised voyages by night as well as day were speedily arranged. But first it was needful to digest fully the conclusions that Professor Tyndall had arrived at from his own experiments, and the results on which he seems to have laid most stress were of the following nature. He, with other chosen observers, would be standing below the indented weather-worn chalk cliffs of the South Foreland, the day still, the sea calm, with no disturbing element in any noisy beat of waves. The sky, perhaps, would be without a cloud, and not a sail visible in the offing. Then his acoustic battery would open overhead, when immediately echoes would be heard, at first with a strength little less than that of direct sound, and then dying away.

"Some hundreds of cannon shots," said the professor, "have been fired at the South Foreland, and never in a single case has a *roulement* been absent."

It must here be stated that this experience was opposed to that of Arago and other eminent observers, and the phenomenon noted admits, as I shall show, of a different interpretation.

Before starting on my own quest, it was necessary to be equipped with reliable meteorological as well as acoustical instruments, and here I was mainly assisted by advice from the leading members of the Aeronautical International Commission. Accurate readings of temperature and humidity were to be kept at frequent intervals, together with corresponding heights, the nature of the ground being traversed, &c., and an experimental voyage, in which I was to be accompanied by Dr. R. Lachlan, of Cambridge, was arranged mainly for practice sake. It led to no very definite results, but was not devoid of interest and teaching.

The ascent was made from the Crystal Palace on an August afternoon, warm and still—so still that we rose practically perpendicularly from the grounds, and for a long time simply soared above them. The air for 2,000 feet was brilliantly clear for photographic purposes. At that height, however, we entered some detached clouds, perfectly opaque to ourselves, and completely shutting out the view of earth, yet friends in the Palace grounds were watching us, and to them the same cloud was as of gossamer, allowing the balloon to be perfectly well seen within it. At this point the strain of a band reached us from below, momentarily, and then died. One thing about it was clear. The musicians were not immediately below us, but somewhat to windward. My aeronautical friend, Mr. Stanley Spencer, had had a similar and yet more striking experience. When at a vastly greater altitude he heard, and as if at no great distance, the fleeting strains of a street organ, which he perceived must have been momentarily wafted up from a village lying in his wake.

The logical inference in my own case is simple enough. The afternoon on earth had been warm as well as still, and off heated areas columns of warmer air were all unseen rising skyward. Yet not truly vertically; this could hardly be so. It is not so with any visible columns that we take cognisance of. The smoke even on the stillest day inclines to windward. The white summer day cloud that suddenly appears as though from nowhere at a moderate height against the blue sky, is but the head of an invisible pillar of moister air that has slanted up the sky, and become condensed into a white tuft or heap on reaching a colder level, but that it has risen sloping up the sky may be judged from the fact that it drifts away on the wind.

Thus then on such a day as that on which we were aloft, the conception was that there were unseen up-draughts of air rising as it were up slanting chimney shafts, and thus chance sounds, ascending through these avenues, would be carried from points not immediately below, but from somewhat on the windward side.

It was not till we reached 3,000 feet, and the cloud had by some trick of magic vanished from all our vast scope into nothingness, that we got wings at last, and bidding farewell to sultry Sydenham, flew leisurely over the Thames, and alighted, as a feather might, at Rainham in Essex.

CHAPTER VI

A LADY AERONAUT

ONLY the vaguest suspicion of any echo from the sky could be caught during the voyage last mentioned, and certainly not to be reckoned as such without good confirmation. Other conditions, other weather, other heights, and other hours, also must be sought and proved, and as advertised ascents are necessarily confined within narrow limits of time, I now decided to take the arrangements into my own hands, and make a fresh experiment after my own inclination. I determined therefore on a private ascent, in which my colleague should be my own daughter, already a practised observer.

As the Palace authorities would fill a balloon for us at two hours' notice, and as that time sufficed also to make the journey from home, I went forward to London as pioneer, leaving the young lady behind, but in readiness to follow instantly on summons by wire. Considerable cyclonic disturbance was passing throughout the day that I arrived in town, and towards evening the captive balloon at Earl's Court had to be hauled down and made snug for the night. But the next morning broke fair and still. The dawn was a wholesome grey, and the early smoke rose straight into an unblemished sky. So full of promise was the day, that at 8 a.m. I simply and confidently wired home a message, consisting of two words only, "Come along."

Thus, ere noon had come, Mr. Stanley Spencer had our balloon laid out, with hose attached, and with all necessary equipment, my daughter and myself, in nautical phrase, "stood by." But we desired to make a high ascent that day, and conditions just then were hardly favourable, for, fine weather signs notwithstanding, the disturbance of the previous day had returned, and the wind from S. by E. blew angrily in gusts. It would be well to wait for some abatement. Nevertheless, come what would, disappointment could not be brooked by any of us, and so the gas was turned on until the silk was half full, and capable of being held down by bags hung round the waist. Next we tried if luncheon would make us regard the weather more kindly, and at 3 p.m. we decided to complete the inflation and abide the issue. But there was to be no turning point in the weather that afternoon, and by the time our balloon was full, and, with ring attached, was struggling restively with the old hands that scarce held her in check, it was clear that further delay was unwise. It was scarcely the right day on which a lady might make her maiden trip, but surrender was out of the question; and mainly to ease our conscience, the idea of a great elevation was abandoned, and in lieu of extra ballast an old sailor aeronaut of long experience was bade get into the rigging as extra help, if such were needed, when we came to ground. And later on the sailor found his work.

We were not duly released until the car had bumped two or three times rudely enough to try the nerve of our young recruit, but we were scarce higher than the great North Tower already behind us when she was on her feet looking sheer down over the rapidly mounting car and steadying her camera for the first "snap."

Luck was all with us now. We had not been away five minutes when I perceived with much satisfaction that our course was to be very nearly that of my own first voyage with Captain Dale ten years before, and this was unusual fortune. The chances are considered about thirty to one against such a course; the usual route in summer, obedient to prevailing winds, lying to the E. and N.E. If one lands on the west side of London there is generally immense excitement among the natives, who will run for miles, trampling down the crops, and ere you can make elbow room and get emptied and packed up there is a dense crowd round you of half crazy countrymen all anxious to drink your health, and each firmly believing that he has saved your lives. On the other hand, if you descend in Essex or on the northern border of Kent you may create but very little sensation, the whole country side being perfectly used to seeing balloons sailing overhead all through the summer.

Ere we had risen a thousand feet it was patent that the view seen from above was going to be much more hazy than on the former occasion when I approached London by sky. This haze is well known to the mountaineer, and has already been accounted for in these pages, but it is a variable quantity, and was one of those conditions which it behoved me as far as possible to investigate. I should mention also another condition which had declared itself. There was a certain languor in the air perfectly well known to sensitive organisations, and very noticeable in animal and insect life. It is often spoken of as an electrical tension or feeling of "thunder in the air," and at such times animals grow restless, midges will bite, and bees become vicious.

There was nothing very noteworthy in the readings of the meteorological instruments, and photography was almost out of the question. What would have been a charming and most interesting view from the Surrey side of Thames, winding and widening out to sea, was but a dim effect of distant haze.

The wind, though of course unfelt, was clearly unabated, and that our wings were those of a strong upper current was certain from the rapid manner in which London began to open out before us. We crossed the Thames at Tower Bridge; threads were stretched across the river in places—these were the bridges—and tiny toy boats were lying in the stream, several hooting loudly.

But already I was struck very forcibly with the *dearth* of sound from the busy centre that we were traversing. Ten years before, when almost at the same date and hour, I crossed the river only half-a-mile higher up, and at nearly the same altitude, the roar from the streets was almost painful, deafening the ear with wild harsh tumultuous sound. But now, though the same discordance was in the air, it was infinitely subdued. The same harsh instrument was sounding, but the full organ was wanting and the swell was closed. It might be questioned whether in the interval of twelve years the increase in the amount of wood paving in the streets, and the adoption of rubber tyres, had appreciably subdued the noise of the traffic. To set against this, however, the number of 'buses and of vehicles generally has certainly much increased—witness the greater number of seriously congested streets and awkward crossings. The main explanation, I am convinced, lay in the fact that the air which was palpably hazy to sight, was also relatively opaque to sound. And we soon had further proof of this. It was over the high ground of the north suburbs that the balloon probably encountered a new and colder current, for it here altered its course more towards the east and began sweeping earthwards. We were descending on open country, consisting mainly of pasture broken here and there by arable ground and occasional woodland, and our descent being gradual we had excellent opportunity of testing at what distances from the earth we could catch the first echoes from the instruments we carried, and to our surprise we discovered that in spite of endless attempts we were considerably less than a thousand feet from the ground ere any echoes could be caught.

In this trial it may be mentioned that we availed ourselves of every variety of country, and it may be of interest to record that character of country makes an appreciable difference. Pastures and ploughed land are not the best reflecting surfaces. A stubble field when the ground is hard baked is better, but woods in full foliage are better still, and so also are level fields of roots well covered with expanded leaves. A certain difference, as I shall show hereafter, is due to the nature of the sounds tested. Unquestionably the best surface for the return of all sounds is that of still, unruffled water.

Ere these engrossing experiments were ended our approach to earth was so very close that prompt decision was needed as to whether we should land or check our downward course while yet there was time. We were reminded of this by cries from a group of people standing in a farmstead just below, who, somewhat disconcerted at the sudden inroad of our trail rope into their precincts, begged us with some energy to "mind the tiles!"

The pressing question was naturally referred to the lady of the party, "Would she like to come down?" but the answer, "Not for hours yet!" given with much emphasis led to an instant discharge of ballast, and we were soon upwards of a mile aloft, flying fast and heading for agricultural land away in Cambridgeshire. In the late near approach to earth, the sun still shining brightly, we attempted more photographs, but with the same ill success and from the same cause already explained. But at length, as the afternoon was well advanced, the chances of meeting with return trains had to be considered. We knew our country well, and felt sure that one of the main Great Northern lines, that from Hitchin to Cambridge, could not be far distant, and that we must cross it with our present course. We were, moreover, descending again, and it would be wise not to venture on another long lift.

So we began to settle down, and in high time, too. The great white road through Royston already lay in the hollow beyond the wooded ridge that we were crossing, and somewhere a little further on would be the steepish cutting of the railway, which, with its frequent trains, would be an awkward object to cope with. Immediately below us, and now quite near, was a large field of corn in shock, and we were yet a good quarter of a mile from the road.

"Down with you, Jack, and let us take care of the lady." This was from our captain, who knew, as did

(From a Photograph by Miss G. Bacon)

DESCENT ACROSS TELEGRAPH WIRES

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all but the young lady herself, that a rough landing was imminent. So Jack was smartly down from the rigging, and there was but time enough to drop the anchor and lessen the fall with a "bag overboard," when we found ourselves in the middle of a shock of corn, and the next moment the car on its side was racing down the field, scattering the sheaves to right and left.

Vainly the trailing anchor tried to get a grip, for the baked earth was hard as iron, while ahead was the half empty silk, carrying us across country with the wind power of a yacht in full sail. I have seldom known a livelier steeplechase, and though during the minutes that it occupied, in the delicious excitement of rapid motion, we mutually assured ourselves that each of us was "all right," yet there was the feeling that surely not far off there must be that ugly ditch with the frequent fast trains.

We had already traversed more than one field without the smallest regard for bounding fences, when we were suddenly brought up on the edge of the white road already mentioned, and then we could survey our position. The balloon lay across the telegraph wires from which we now were fairly suspended. The railway was but another hundred yards further on. We could now disembark, but it required all the help we could get, and all the cunning of the sailor, to disentangle ourselves and get the wreckage clear.

CHAPTER VII

HOW ARE SOUNDS CARRIED?

Fresh questions of a highly interesting character suggested themselves as the outcome of the day's experience just recounted. First among these was the marked impediment to the passage of sound. Two reasonable causes might be put forward, namely, the strength of the wind and the haziness of the air, at least as seen from aloft. Would the swift movement of the balloon mar the echo which should be heard off the earth? Surely not to an appreciable degree. Echoes were lost at 900 feet that day, or in other words, the interval of time that would have been occupied in obtaining an echo off the ground from the balloon would have been little more than 1½ seconds, in which time the balloon, flying at about 30 miles an hour, would not have drifted as much as 25 yards, a distance relatively far too small to affect materially the reflection of a sound-wave off the distant earth. Moreover, direct sounds off the earth had been quenched, and, according to accepted theories as

I have stated, a wind blowing horizontally could not account for this.

Would, however, the haze in the air afford the desired explanation? To this question another voyage, undertaken very shortly afterwards, will give a sufficiently pertinent reply. A far more hopeful explanation lay in the "thundery" state of the air, which had been so noticeable. It is a fact to which frequent attention has been called, that thunder is not heard at any great distance; certainly not nearly so far as might naturally be supposed. If attention be paid to a thunderstorm in the middle of a summer night, while the house is perfectly still and no other sounds are in the air, when we will also presume the window is at least partially open (?), it will be found that a peal of thunder is seldom heard as late as half a minute after the flash, and if it be then heard it is only faintly, and has to be intently listened for. And yet in that case the terrific uproar—the loudest sound on earth—is only some six miles distant, not a quarter the distance at which a field gun at Aldershot will be heard loudly and in daytime; and if it be contended that in the case of a gun it is the earth that helps to convey the sound, I shall show in a future chapter, where I describe my bombardment of London from the clouds, that a single discharge of my purely aerial artillery was heard at greater range, and so loudly as to rouse the attention of the casual man in the street, despite the houses and the noise around.

I have ventured to speak of thunder as the loudest sound on earth, but I have used the expression on reliable authority. I take for granted that no more deafening noise was ever created by man on the face of this planet than by the combined armies at the close of the siege of Sebastopol. Sir W. H. Russell describes it on a day when the cannonade was at its height, but before he finishes his despatch at 2 a.m. he adds a note about a storm that had just passed overhead in which the peals of thunder exceeded the report of cannon. "There is," he said, "a great battle raging in the sky, and its thunder mocks to scorn our heaviest cannonade." If, then, at a time when there is electrical tension in the air the maximum noise that we know of is only heard at a very limited distance, it would naturally be inferred that the noise if not actually absorbed must be returned, and here we have at once sufficient cause to account for the supreme and long continuing reverberation of an ordinary thunderclap.

It is generally asserted that these reverberations are flung back from the hollows of the surrounding clouds. Be it so; but I shall give conclusive proof that clouds, even the densest and the wettest, will, under ordinary conditions of atmosphere, give back not the slightest reverberation whatever.

It will now be asked whether on the thundery feeling afternoon that I have described, and when the sounds were quickly quenched, we met with anything like an echo from surrounding air. Well, once or twice we certainly thought so, and indeed entered a memorandum to that effect, but before relating our experience I will give that of a well-known observer of long ago.

Mr. Wise, the father of aeronautics in America, was ballooning in the States above a dense cloud stream when he heard a cow-bell and the sounds of a wood-chopper's axe, whereupon to attract the attention of the labourer he shouted "Halloo!" which elicited a "Halloo!" from the ground in response. He then asked the question, "How far is this from Lancaster?" and was annoyed with being mocked by his own words. "Being in the clouds," he continues, "and not able to see things either above or below, I felt somewhat nettled at such clownish display of wit, and in a very audible tone of voice, while the foregoing was still reverberating in my ear, sung out, 'You're a fool!' which in a very few seconds was answered by an equally distinct and measured tone of voice, 'You're a fool,' when it suddenly flashed upon my mind that it was the echo of my own voice, which opinion was ratified by the dying reverberations of my words, which had now become as numerous as though a whole regiment had caught the watchword, and were passing it in quick succession through the whole line."

Now, be it noted, that though my colleagues and myself have tested the echoes of a shout or the blast of a horn times out of number, under all sorts of circumstances, we have never obtained a multiple echo from sounds of that nature off any variety of ground over which we have travelled. Long drawn out reverberations, however, similar to those described by Mr. Wise, we have heard often enough, but they have invariably been traced to the hollow cavern of the globe above us, in which a shout will sometimes echo on interminably, but, owing probably in part to the nature of the gas within, apparently as if from a great distance.

I have since been quite convinced that on the day of our travel over London last related, our suspected aerial echoes came simply from the cavern of the balloon overhead.

I have noted that Mr. Glaisher on one occasion, in the same month of the year, namely August, followed almost our identical route, and recorded that when over St. Mark's, Kennington, and at a height of one mile, he first heard the hum of London. This was certainly much better hearing than in our own case during the afternoon now in question. M. Flammarion has actually given us a table of heights at which certain sounds can be heard. Thus he says the whistle of a locomotive rises to near 10,000 feet, the noise of a railway train to 8,200, the bark of a dog to 5,900, the crow of a cock and the sound of a bell to 5,000, and so on. But it should need no insistence that these statements cannot be accepted as exact, and it has already been made clear that varying conditions must greatly affect results.

As one example of the loose statements sometimes indulged in by aeronauts in describing physical phenomena, we may cite Lunardi, who gravely relates how, after calling aloud, he heard the echo of his words "returned after the third of a minute, or nineteen seconds, as loud as they were pronounced." This would mean simply that at a height of two miles, or higher than the longest range of any sound as just mentioned by M. Flammarion, he hears his own words echoed back, and as loudly as he himself had spoken them. There can be no question as to the gross exaggeration of this statement.

To those who are curious about echoes heard on the earth, it may be mentioned that not a few famous examples have become impaired, or else have disappeared altogether, and this doubtless owing to some change in surroundings perhaps not always apparent. Echoes love surprises. A striking effect was produced in that scarcely romantic locality, the Strand, on the day of the relief of Ladysmith. It was mid-day, and the unusual stir in the streets, added to the general noise of the traffic, made distant sounds difficult to hear at the west end of that busy thoroughfare. So that, happening to be walking on the south pavement, near the top of Villiers Street, and hearing the bells of St. Martin's suddenly ring out in joyous peal, I was not surprised to notice that their sound was almost completely drowned. Turning however into the open space in front of Charing Cross Station, and advancing a few paces along the pavement, the sound of the bells suddenly opened out with startling crash, though it was almost impossible to credit that this came from St. Martin's tower. From some lofty belfry, as it seemed at the back of the hotel, a full peal of giant power was ringing. Anyone who stands on the spot can see at once what happened. The true sound, say 200 yards distant, found a direct passage down the slant opening of Duncannon Street, and striking the broad face of the hotel, was redoubled round the station yard and brought to a practical focus about the spot I have mentioned.

The remarkable intensity of the echo here was of course due to a purely fortuitous combination of causes, and it will hereafter be shown that on the other hand mere chance has unexpectedly banished the mocking voice from many an echo haunt. It was not long after the date of my last mentioned aeronautical experience that I had valuable opportunity of investigating afresh from aloft the behaviour of ground echoes. I had ascended again from the Crystal Palace at about the same hour in the afternoon, on a day that was equally brilliant below, and when general meteorological conditions were fairly similar. Moreover, the afternoon proved a repetition of the former one, in the fact that a strongly pronounced haze at once declared itself as soon as we had ascended a few hundred feet.

In a photograph which I secured of the open country, when flying at about 1,200 feet, a very clearly defined shadow of the balloon was thrown on a field below, showing the great brilliance of the sun at the moment, and yet the whole picture is shrouded in haze. It then became a question of great interest to discover if acoustical conditions tallied with those noticed on the former similar occasion. On that occasion echoes off the ground had, as I have stated, been always lost at a thousand feet, but on this afternoon they were heard repeatedly even up to an altitude of 2,500 feet. The mere particles of matter in suspension lying chiefly at lower levels would then appear to have little or no effect on the travel of sound.

This fact had another illustration as our voyage proceeded, for chance took us high over Chatham, and at one spot directly ahead of us we saw a group of soldiers hastily clustering together, obviously attracted by our approach. Then, waiting till we were immediately overhead, a bugler sounded a familiar call. I much regretted that I could not interpret the message thus conveyed, but I replied with a blast on a hunting horn, and do not doubt that I was well heard. At any rate, the bugle below sounded in our ears as loudly as if we had been in the barrack yard itself; and, of course, it was more than possible that the sound was intensified by reverberation from the blocks of buildings ranged symmetrically around.

Other sounds were equally penetrating that afternoon up to considerable altitudes, such as trains on the L.C.D.R., and rifle shots on ranges, invisible through distance. And this audibility characterised the condition of the atmosphere up to the time when evening shadows were darkening the fields far down. We were at that time nearing Canterbury, and had remarked that our course was almost identically that of the famous voyage of the Nassau balloon, so that having sufficient ballast we were sorely tempted to essay a cross channel trip, from which we were only hindered by reason of our being due to make an ascent with the same balloon at the British Association Meeting at Bristol two days later. A thickly timbered country was rapidly approaching, making it desirable to descend at once, which we proceeded to do ; but on nearing the earth we perceived what the gathering gloom had hitherto hidden, that the whole locality consisted of hop-gardens in full bearing, any interference with which would probably entail a claim for considerable damages.

We therefore promptly discharged a bag of ballast—one bag only—but the effect was to give us one of those extraordinary giant strides of which I have already spoken ; and shooting up to 4,000 feet, where, it should be mentioned, the air was sensibly warmer and the sun still shining, we did not come near the earth again till we had covered many miles.

A noteworthy circumstance occurred in the interval. We had been looking for the opportunity of dropping some missive into the town of Canterbury, in imitation of the famous Nassau voyagers, who, we remembered, despatched by parachute a complimentary message to the Mayor of the ancient city as they sailed over the house-tops. But in this attempt we were disappointed. Our course, as we proceeded, bent to the right and took us at least two miles to the south of the town, towards which we had seemed to be directly heading. Now this divergence was in accord, not only with former experience of our own, but also with continental balloonists who have written on the subject, and it is one that would well repay discussion.

It was not till the sun sank for good behind a low bank of cloud in the far west that our balloon spontaneously settled earthwards, when, reaching colder layers below, its descent became rapid, clearly indicating the termination of our aerial journey unless more ballast were quickly discharged. We were swooping down close to the small station, Addisham, on the L.C.D.R. line, between Canterbury and Dover, nine miles from the sea. It was shortly after passing Faversham (always readily distinguished by its skeleton church tower), and just before the wooded high ground to the east was reached, that the former bag of sand had been thrown out, and the result of this had been a fresh flight into the skies, lasting for three-quarters of an hour, and now about to terminate a good twelve miles away. It would be not unreasonable to suppose that with another bag overboard the balloon, if left to itself, might take another giant leap and land us somewhere off the Goodwins. This was not desirable; moreover, the light was fast vanishing, and it was already difficult to distinguish objects on the earth. Soon, however, we could see that we were over a large field apparently devoid of crops. The railway was not half a mile distant, and we were not desirous of more conflict with telegraph wires. So promptly resolving to try our luck, we opened the valve. It was a plunge into darkness such as I had not known before, and a quarter of a mile of blind tobogganing before our anchor held was a new experience. It led also to an amusing incident.

Countrymen had, as usual, seen us in the air as we came earthwards, and they were already running up from all quarters. But though the dusky monster had been descried against the sky, it was no longer visible when on the ground, save at a few yards' distance. Thus our dragging along the earth had had the result of misleading our pursuers, who, now at fault some hundreds of yards away, could not tell what had become of us.

Then it occurred to us to lie hidden, and, as a study of rustic nature, to see what would transpire. So we crouched in the bottom of the car, now lying on its side, and listened through chinks in the basket work. In front of us lay the great mass of half empty silk, dimly seen and floundering and flapping in the gusts of wind like some stranded leviathan in its last throes.

There were voices in the distance, emphatic exclamations, loud shoutings in question and answer, and here and there the noise as of hedges being broken through. After a little while a nearer voice, "Here 'er be!" and then a view holloa.

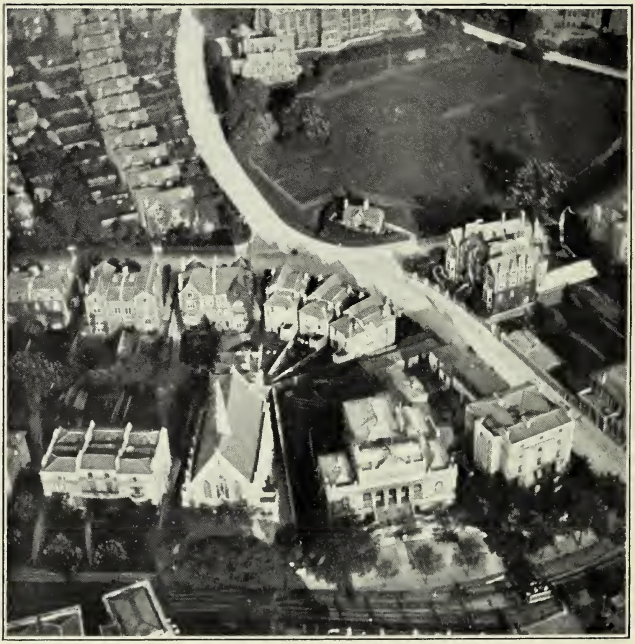
We were discovered at last, and then a confused babel drew near. There was a crowd coming up; but presently they halted, breathing hard, and someone asked "What be 'er?" And still the long length of the half-inflated balloon surged and flapped in the darkness. Very cautiously the bolder ones drew nearer, and feeling the car nervously with their hands, finally looked in, but shied off again with a start on being greeted with a shout of laughter from within.

CHAPTER VIII

A SCIENTIFIC ASCENT AT THE BRITISH ASSOCIATION

Two days later, on a glorious afternoon, Clifton College was en fête in honour of the meeting of the British Association at Bristol, and a garden party had been arranged on a superb scale and with lavish hospitality. The entertainment included a most attractive programme, of which one item, and certainly not the least popular, was a balloon ascent, announced to take place at 5 p.m.

Towards this end, an elegant balloon of 40,000 cubic feet had been brought down by Mr. Percival Spencer over night, and was in process of filling ere mid-day at the hands of the Bristol Gas Company, who had not only arranged for a splendid service of gas, but had most generously borne the entire expense of inflation. So excellent were the preparations, that there could be no doubt of a well-filled balloon, and as there would be only two occupants of the car, we resolved on attaining a lofty altitude, and I took up a large glass flask, exhausted for me to a



(From a Photograph by the Rev. J. M. Bacon)

A THOUSAND FEET OVER CLIFTON

(p. 89)

high vacuum in the well-equipped laboratory of the College, its purpose being to bottle off at our greatest height a sample of air, which Professor Ramsay very kindly undertook to analyse.

The exceptional weather of a brilliant and long-lasting summer was still continuing, but the hour of ascent being late for an afternoon in mid-September, it seemed almost absurd to attempt snapshot photography with the small Kodak camera which, from its portability and security against injury, I was in the habit of taking up with me in our car. Moreover, on the last two voyages, as mentioned, a persistent haze, manifest at a little height above the earth, seemed in any case to render successful aerial photography almost out of the question. But one learns in matters experimental to prove all things, and to be prepared for many surprises.

As it turned out results were altogether astonishing, for it was 5.10 p.m. when we left the earth, and a snapshot taken at the moment of departure showed very lengthened shadows projected on the ground. Still the photograph was bright and sharp beyond all expectation, as also was a second one of the same group after we had risen well above the housetops. At 6.20 we were nearly one thousand feet above a conspicuous church on high ground, surrounded by clean white streets and modern houses, and offering a well illuminated picture with strong contrasts, which were greatly in favour of the camera. Here again an instantaneous photograph proved all that could be desired.

Then the balloon swung and brought me once more facing the spot we had recently left, the College Green fast receding in the distance, with a scattered group of tiny black and white dots, representing the crowd of visitors still gazing at us. Beyond this lay the outskirts of Clifton towards the Downs, and the winding course of the Avon, silvered with the slanting rays of the sun, and bridged across its heights with what might be taken for the thread of a spider's web. It was a fairy scene not to be surpassed, but it lay under the western sky, and a haze was there which the camera only magnified. Nevertheless, a few minutes later, from an altitude of 2,000 feet, we looked down over the whole extent of Bristol, only it was Bristol idealised. A fair and peaceful city was stretched below us that lovely September evening, and though the hour was now 5.30, and the autumn sun within fifty minutes of its setting, yet a perfectly instantaneous picture was taken on a Kodak film in which there is not a trace of haze nor a vestige of Bristol smoke.

This was altogether a record in aerial photography, for which on the face of things there was apparently no sufficient cause, and it became a matter of great interest to discover some probable explanation. As usual, throughout the long unvarying drought of many weeks past, mere readings of meteorological instruments at the level of earth had foretold no coming change in weather, nor given any indication of the conditions prevailing only a furlong up in the clear above.

But as soon as the camera had been laid aside, and the instruments, whose last readings had been taken on the earth, were again consulted, an unexpected state of things was at once apparent. Before we had reached the open country those who were watching us from below noticed that our course took a sudden bend from E. to S.E., and at that period we recorded that the temperature sank in a marked degree, and that the air grew more moist than we had found it throughout the entire season. Clearly a colder air from the N.W. was settling earthwards, replacing the dry dust-laden lower stratum with a moister and more transparent atmosphere. Ere three days were over this fact was made patent to all the British Isles, for there followed during a brief interval the only break in the long cloudless drought of that extraordinary summer.

But we were by this time made aware that we were out of our reckoning as regards our sky-pilotage. In spite of our small weight and large balloon we were clearly not destined to make any lofty ascent. On the contrary, we were parting with our ballast rapidly, and though the late hour and colder upper current would in part account for this, yet there must be further cause for the lack of our ascending power, and it was Professor Ramsay himself who subsequently suggested that a sufficient explanation might lie merely in the nature of the gas.

It is commonly stated that the better the illuminating quality of gas the less well-fitted is it for purposes of the aeronaut, and conversely. And this statement may be accepted as fairly correct. Coal gas, speaking generally, is about half as heavy as air at the surface of the earth; but whatever coal it is derived from, the portion first given off is heavier and richer in carbon than the latter portion. Thus a ton of good bituminous coal may be reckoned to produce about 10,000 cubic feet of gas suited for lighting or heating purposes, but it will yield a further quantity, which, though specifically lighter, is unfit for the ordinary consumer, so that it is not uncommon to find gas works that yield a quality of gas excellent for the town supply, but ill-adapted for the balloonist. Again ordinary coal gas or carburetted hydrogen, as it is somewhat loosely called, is very apt to become mixed with another gas which is almost as heavy as air itself, exceedingly poisonous and in all ways objectionable. This is known as carbonic oxide gas or technically CO, and is very frequently seen at the top of the fire in an ordinary grate burning in the chimney current of fresh air, with a lambent blue flame.

It will be easy to see then that without a practical test, the lifting power of any particular supply of gas cannot be determined, and, as a matter of fact, the only practical test made at any ascent is that by the balloon itself, when the hour for the start has arrived and when there is no longer opportunity to mend matters.

Part of my experimental work on this day dealing with refraction was to endeavour to snapshot the sun disappearing behind the sea horizon, and with a hope of accomplishing this just as the sun was sinking below a murky skyline, we threw out our entire remaining sand with the result that the sun climbing out of the west, rose for us once more and surmounted for the time an ominous streak of distant orange that blotted out the true horizon. It was then that we noticed a curious thing—not curious in itself, but passing strange by reason of its environment—a globe of thistledown came floating up from below us, and winging its way with the wayward flight peculiar to its kind, coquetted a moment with our balloon and then passed upward climbing into the sky above us, although at that moment we ourselves were rising. There was teaching in this trivial circumstance, for the little wanderer was, of course, travelling with the wind as we were, but it was also ascending by means which were incapable of influencing our own vast globe above.

The reason of this could not be doubtful. Volumes of air rarefied by contact with heated patches of earth below were rising into the colder upper region, not in any considerable uprush however, but in devious streams or rather rivulets. This is the way with gentle air-currents. If an unsnuffed dip candle is blown out in a room in which there is a strong draught towards the fireplace, a thin line of white smoke starts away for the chimney—not spreading to any great extent, but making an irregular track of its own. And air currents commonly break up into streamlets of this nature, as anyone may see who watches how gentle gusts will stir herbage not with one broad sweep, but in patches here and there, careering across a field in whirling zig-zag fashion like leaves racing down the road. The updraught of air from below was not rising as a tide capable of bearing our balloon on its flood, but rather with twisting eddies which could sport with a tiny seed, flinging it hither and thither skyward.

There was to be no high flying for ourselves. The impetus we gained by parting with our remaining sand was soon checked by sheer fall of temperature. The sun that was sinking again suddenly disappeared behind a cloud streak, leaving a chill in the air which quickly caused a shrinkage of the gas, and we were soon descending at considerable speed. Our fall commenced several thousand feet up, and it became apparent from the pace with which the earth came surging up towards us that we must be prepared for a somewhat severe impact with the ground, a fact which gave me much concern on account of the instruments which I carried, and which did not admit of careful packing in the brief interval now left us.

But the chances in sky travelling are past guessing at. We were descending on to the rich pasture land near Frome, and our apparent landing ground became hidden by a wood of some extent, over which we were shooting. But our fall was even yet more rapid than we thought, and we came crashing into the wood itself. There was a whipping and bending of branches, a snapping of twigs, a smart brush in the face, and then the stout pliant branch of an oak fairly flung us clear into space once more, leaving us to drop in a paddock beyond as softly as a feather.

Once during the voyage last recounted a cloudlet level with the car wandered by at no great distance, and I challenged it loudly with a hunting horn, with a shout and with a clap of the hands, but elicited not the slightest response, although at the altitude at which we then were sailing the faintest sound strikes on the ear with startling distinctness.

But I am wrong in saying that the cloudlet wandered by. It really kept us company till, in a brief moment, it vanished into that other invisible world whence it had come. The sky would really have been described as cloudless, but out of the void this aerial phantom had come and gone, tarrying only long enough to be seen and marvelled at. We were on the border land of moist and dry air, and any slight changes of temperature due to wind currents, might suffice to cause a wreath of vapour to condense and again evaporate.

Some very extraordinary differences of temperature in contiguous layers of air are sometimes to be noted. MM. Bixio and Barral, two scientific Parisian aeronauts, have recorded that at a height of about 20,000 feet the temperature fell in traversing two thousand feet only from 18° F. to 39° below zero. This unconscionable fall took place in actual cloud. On this occasion a curious optical phenomenon presented itself. As they were passing to the upper limit of the cloud the sun's orb shone pale through the thinning veil above, while a second sun was reflected below as in a pool of water.

Under somewhat similar conditions a true mirage may also be observed. M. Gaston Tisandier was sailing the sky somewhere over Calais, when turning his face northward he noticed that the coast of England was hidden by a vast veil of leaden cloud, above which was a greenish layer like that of the surface of the sea bearing a little black spot the size of a walnut shell. This spot proved to be a ship sailing upside down, being in fact the mirage image of the Dover packet-boat.

I have insisted, and shall have to insist again, that I have never obtained an echo from a cloud, either from a hollow of such cloud, from the under surface of a cloud canopy, or from the upper surface of a cloud floor, and this negative result has always attended my experiments, which have probably been the most complete yet attempted, and often carried on for hours under varying conditions of cloud, while every species of sound has been made trial of, including the tremendous reports from service fog signals, of which I shall have more than one tale to tell.

The few instances recorded of such echoes do not seem to me conclusive. Thus M. de Fonvielle speaks of hearing echoes from a cloud below, but mentions incidentally that he was near enough the earth to hear the "cackling of chickens." Must not then the cloud have been transparent instead of impervious to sound, allowing the cackling to be heard, as also the echo which really came from the surface of mother earth? M. Flammarion states as the result of his own ballooning experience, which has been considerable, that cloud or fog aids sound, and whenever in passing through a cloud a band has been heard below, the music has always seemed to be close at hand. This, as will appear later on, is more in accord with usual observations.

My own pursuit of echoes was becoming all-engrossing, the more so as those that were credited with tenanting the skies were always escaping me. With the purpose of learning then more of their ways and haunts I determined if it were possible to carry out careful experiments in that spot, which of all others may be considered their most hallowed sanctuary—the interior of St. Paul's Cathedral and more particularly the famous Whispering Gallery. Cavallo more than a hundred years before had carried out scientific experiments from the dome. Brewster has dealt with its mysteries; and Herschel speaks of the effects of the wonderful gallery in terms which had always led me to believe that he had personally studied them. I believe this, however, no longer, and rightly to explain my scepticism I must begin my story at the beginning.

CHAPTER IX

A MIDNIGHT EXPERIENCE IN ST. PAUL'S CATHEDRAL

Ten years before the time of which I am now writing I conceived a fascination for those electrical disturbances in the earth that are known by the name of Variations of the Earth's Magnetism. An instrument is kept going at Greenwich consisting essentially of a magnet slung by a double thread, and carrying a light mirror which reflects a spot of light on a ribbon of photographic paper moved continuously forward by clockwork. This spot of light is constantly moving about, owing to magnetic changes occurring in the earth, and at the end of twenty-four hours there is traced out a jagged outline of mountains and valleys very similar to those which are recorded by other self-registering instruments, and with which we are all tolerably familiar. During the same twenty-four hours a like tracing will have been produced by a similar instrument at Kew, but the two tracings will not be identical; and to notice where the two records emanating from stations only twelve miles apart agree, and also where they disagree, is a very curious study indeed.

Be it mentioned here, however, that the night readings are in many ways the most interesting, as well as the most reliable. Local and accidental causes may, and do create disturbance, and as an instance of this the Greenwich instrument is so beautifully sensitive that it will make a private memorandum of its own regarding the daily working of the Electric Railway near London Bridge.

It had occurred to me that records most interesting and valuable for comparison might be made at some point midway between the two Government Observatories, and St. Paul's Cathedral appeared in many respects an ideal station. It is distant five miles from the Observatory of Greenwich, and eight from that of Kew, nearly on a straight line drawn between the two places. Then the Crypt affords an admirable subterranean chamber, while the Golden Ball is another point of vantage, nearly 400 feet vertically overhead, and easily accessible.

Before my project could be carried into effect it was first of all necessary to show that it was thoroughly legitimate and reasonable, and I was quite prepared to find that an eminent divine, whose bent was in altogether another channel, might regard scientific experiments from another point of view than my own, and recommend their being carried out elsewhere rather than in the cathedral entrusted to his care.

Dean Church, however, was hampered by no narrowness of vision, and, with courtesy and large-heartedness never surpassed, granted me the permission I sought, merely stipulating that I should place myself under the guidance of his own head verger, who had held office in the cathedral for thirty years.

I now provided myself with two identical instruments, made sufficiently portable, but constructed on the lines of those already described, and took with me as colleague a young electrical engineer. At 9 p.m. on a warm midsummer night we presented ourselves, according to agreement, at a small side iron door, scarcely known to the public, where we were admitted by a janitor carrying a lantern, and after traversing a long narrow stone passage we emerged in semi-darkness under the dome. Here we were met by the genial and venerable Mr. Green, the Dean's Verger aforesaid, who explained the arrangements he had made for us. Certain gas lamps had been left up the staircase burning for our special benefit to illuminate awkward landings and the many upright ladders in the long, dark ascent above the dome. Free access was granted us to those parts of the building which we desired to occupy. A separate safety lamp, well trimmed, was given to each of us, and for the rest we were handed over to the care of the watchman of the night.

I am not likely to forget that night. We had come essentially for scientific work, but the mind was irresistibly held by other thoughts as well. A single gas jet was burning in the choir, serving only to make more visible the solemn darkness of the silent pile. Silent it was to the verge of awesomeness, and one's footfall on the flags was echoed back everywhere from walls and groined roofs, lingering last in the black cavern of the dome high above. The hour and place, so familiar and yet so unreal in the darkness and silence, tempted one to yield to delicious reverie; but a night's work was before us, and ere the chimes declared it ten o'clock we were at our respective posts—myself alone on the topmost ladder, my colleague in like solitude watching in the Crypt 350 feet below. We remained thus till midnight, and I have by me a memorandum which I jotted down by way of keeping awake between the intervals of taking readings. It runs thus: "A grated window, eighteen inches square, half way up my ladder, affords me a view of the great world outside, which becomes a complete panorama whenever I mount into the narrow stone opening under the great ball, a feat which I perform as often as I feel disposed to meet the rude buffeting of a tremendous blast of cold, but most refreshing air. The roar and rattle up from the streets below, which was so striking two hours ago, reaches me now near midnight as a distant murmur, scarcely more noticeable than as I heard it two years ago from a balloon 3,000 feet almost directly above my present station. The frequent railway whistles, however, are borne in from all quarters, and apparently from great distances, and every now and then there is the unmistakable fog-horn of a passing bicycle. But the great charm is in the fading light and the comparative repose that gradually settles down upon the restless city. The rows of lamps still map out the well-known thoroughfares and trace the bridges, and even here and there show by reflected light the flow of Father Thames. These are the night-lights left burning while London herself has gone to sleep. One light continues to puzzle me. Away due east, perhaps 1½ miles off, and in quite the poorest quarter, is a most conspicuous and brilliant blaze, like a great beacon, and far the brightest object in view."

That blaze in the east I never determined, though I made inquiries through the press. Might it be that, owing to its surpassing brilliancy, the light was much further away than it appeared to be; in which case it may have been connected with the shipping in the neighbourhood of Blackwall.

It was agreed that I was to be relieved by my partner at midnight, and I was listening for the hour to strike with close attention for fear of its escaping me. There was small chance of this, however, for the City proclaimed the hour in a manner I was quite unprepared for. And not the City only. All London and the suburbs joined in as well. Owing to the quiet that now prevailed, added to the great elevation of my watch-tower, and the free access of sound, every belfry for many miles round must have swelled the wild chorus that now broke out. It was some neighbouring upstart tower far below me that led off in hasty, fussy fashion, rattling through its part alone. This was by way of recitative. But St. Paul's broke in reprovingly, the chimes thundering out of the northwest tower as never heard before; followed after a dignified silence by the deep full stroke on the tenor, which sent a tremble through the air. By this time there was mad frenzy everywhere. From every quarter the strife of iron tongues mingled in Babel indescribable. It was quite a long while before all was over and peace restored, and even then one or two feebler voices contested querulously who should have the last word.

Almost directly after the clocks had ceased striking I heard my friend's footfall on the steps below, and called out to him "You're almost before your time!" And this was with reason, for he was not to desert his instrument till twelve o'clock, and it would take him a quarter of an hour to reach the perch where I was seated. But I got no answer, and presently I called again, when he apparently was not many feet below. Then I found that my loudest shouting failed to reach him, and this might well be, for it was full ten minutes before he heard me, during all which time he had been climbing steadily; and when at last he replied he was still some flights below.

I have recorded this occurrence at length, because it appears to me one of the most remarkable acoustic phenomena, of which there are many in St. Paul's. The simple fact was that the earliest footfalls on the broad steps of the lowest staircase were carried upwards with such intensity that they appeared but a few feet away. A speaking tube would not have carried sounds through such a range with equal distinctness. Doubtless allowance must be made for the extreme silence of the place, and for the fact that the ear had been kept at close attention. But the phenomenon is certainly a most striking one when one considers the many ins and outs, the doorways and landings that bar the passage up the long, winding ascent.

At 3 a.m. our vigil had ended, and we were free for an hour to turn our minds to other investigation. The night watchman was able, consistently with his duty, to introduce us to some of the penetralia of the vast building. He assured us, however, that having been only five years at his present post, he as yet knew comparatively little of the endless intricacies of the place. This sounded somewhat strange, till we discovered, as we soon did, that a rabbit-warren would be a mere joke to that stone labyrinth.

The entire walls seem to be hollow with passageways running simply everywhere—downwards and upwards, crossing and re-crossing in all directions, while every niche almost is a trap-door and every column a staircase. Chambers and recesses are without end, and often on a lavish scale; workshops, a mason's yard, lead foundries, engine-rooms, museums, libraries, and store-rooms without number, all included above ground or below within the boundary railing of the churchyard.

The Whispering Gallery then claimed our attention. And here, surely, was the greatest surprise of all. I had often investigated its mysteries in the ordinary way and in day-time, but thus one gets no adequate idea at all of the real acoustic wonder. How is it possible with the tumult of noise from within and without that distracts the ear and masks the fainter sounds? Now in the hush of the breathless summer night the carrying power of the huge vaulted enclosure was astonishing. A whisper travelled round the vast circle with no apparent diminution of power, and I speak of the sound *travelling* round because that was distinctly the impression conveyed. The most striking effect was caused by breathing some whispered words *against* the wall, when they were heard by a listener whose ear was applied to the wall on the opposite side far louder than when the attempt was made simply to whisper *across* the open area. But yet more curious was the result when the listener stood at some point round the gallery not exactly opposite the speaker, for in this case the latter's words were heard twice over.

Ten years later, when it came about, in the manner which I have described, that I desired to re-investigate the acoustic wonder of the gallery, I sought first of all to make myself acquainted with what had been written on the matter by experimentalists in bygone times. Professor Tyndall, referring to this echo, cites Sir John Herschel, who states that the faintest sound is conveyed from one side to the other of the dome, *but is not heard at any intermediate point.*

This was enough, for neither Tyndall or Herschel would have been capable of an inaccuracy in regard to any strict observation of their own, and it was now quite clear that neither had investigated the echoes of St. Paul's at least with adequate care, or in silent hours. Sir John Herschel's very definition of an echo is indeed astonishing. He writes in his classical article in the *Encyclopædia Metropolitana* that an echo depends on sound "meeting with an obstacle of sufficient extent and regularity." Now the simple fact is that nothing will give back an echo more readily than trees, more particularly when in foliage, and yet such an obstacle is the very opposite of what Herschel can have meant by one of "sufficient extent and regularity."

If you stand in an open space where there are no surrounding obstacles soever, save isolated trees, at say some eighty yards' distance, you may shout, but the voice will not return. A clap of the hand, on the contrary, will come back distinctly from every tree around. The report of a gun will return off a clump of trees a quarter of a mile away or more, while a service fog signal will arouse a thunder of its own in a woodland district for a mile around. These echoes, however, are in a high key, and this may be readily accounted for.

Small opposing surfaces, such as leaves and twigs of trees, will throw back the smaller, and presumably higher pitched waves, while they may fail to return those of graver pitch. We have an analogous phenomenon in the case of the reflection of waves of light. The lower levels of our atmosphere contain a multitude of minute particles in suspension, which must be capable to some extent of impeding solar rays, though they principally act as obstacles only to the smaller and shorter; that is, to the blue rays of the spectrum. Thus it follows that the light thrown back from the open sky is mainly blue. Further, in Professor Tyndall's own words, "as the sun sinks towards the horizon, the atmospheric distance increases, and consequently the number of the reflected particles. They weaken in succession the violet, the indigo, the blue, and even disturb the proportion of green. The transmitted light, under such circumstances, must pass from yellow through orange to red. This also is exactly what we find in nature. Thus, while the reflected light gives us at noon the deep azure of the Alpine skies, the transmitted light gives us at sunset the warm crimson of the Alpine snows."

Everyone must have noticed the remarkable, sharp, almost metallic ring of his footsteps on pavement when echoed off narrow palings bounding the opposite side of the roadway. This is another example of the peculiar nature of echoes reflected from small surfaces. Standing a little way in front of palings formed of about $2\frac{1}{2}$-inch battens with 2-inch interval, and clapping the hands, echo exactly mocks the sound, but standing at an angle to the face of the palings, so that only the mere edge or arris of each batten can now reflect the sound-waves (and of these presumably only the smallest) echo still replies, but with a high-pitched "chirrup" lengthened out as it comes back from far along the fencing.

Profiting by experience of these results, it was our first care in the Whispering Gallery to arrange that each observer should stand against the wall, having the head well above the level of the heavy inner railings. It soon became clear that the echoes were of a most complex kind. A multitude of spirit voices were around, which could be evoked in various ways and by various means. Experiments were made with sounds produced in many ways—by the voice, by a tuning-fork, reeds, the scratch of a pin, &c. With the majority of these trials we noticed that the sounds which were heard very distinctly close against the wall faded as the ear was withdrawn from the wall, which seemed at once to dispose of that theory which made reflection from the opposite parts of the dome the sole cause of the phenomenon. Of course, echoes could be got in that way, infinite in number, in which case sound came back and back in manifold reflections, after the manner in which a billiard-ball will travel in an angular course round and round a quick-running table. But in the case of the true "whisper" of the gallery delivered against the face of the wall, and travelling round as already described, the result rather indicated that the sound *hugged* the wall, and as it were rolled round it more as a ball hugs the circular end of a bagatelle board. And this is not hard to conceive. Driving smoke will hug a wall and roll along it, and though sound is due, not to moving air, but to wave motion in the air, yet fluids are always in a condition of special tension along the surfaces that bound and restrain them, and along such surface of special tension vibrations of an enhanced order may reasonably travel.

Another proof of how sound will hug the side of a circular wall is afforded elsewhere in St. Paul's Cathedral. Far away in the recesses of the building forbidden to the public and reached only after much climbing and the traversing of many devious passages, you gain admittance to the chamber where hangs Great Paul, the mightiest bell in the British Isles. I have had the privilege on several occasions of experimenting with this mammoth instrument, and may be pardoned if I digress somewhat in giving some description of it.

CHAPTER X

NOTES BY THE WAY

UNTIL 1882 the largest bell in England was Big Ben, weighing 13 tons 11 cwt., incapable, however, of being rung. Tom of Oxford then ranked as a big bell, though only scaling 7 tons 12 cwt., and capable only of being chimed or struck with a hammer, when, according to Lord Grimthorpe, it gives out a "weak and abominable sound." The great tenor known as Peter of York, that has hung in York Minster since 1845, weighs 10 tons 15 cwt. But Great Paul, with a weight close on 17 tons, can be rung up by the combined labour of four men until he is swinging through 120°, and both sides are thundering with the crashing blows of a clapper which of itself weighs a third of a ton.

Now be it mentioned that though the usual approach to the monster's retreat is so bewilderingly circuitous, he really hangs simply in the south-west tower, a short climb above the clock, and so buried is he in the solid masonry that, though rung every day, London is not aware of the fact. On one occasion, having permission to be present at the ringing, I enquired at a principal shop in Cheapside at what hour this would be, and was not a little astonished when the shopman obstinately denied that the bell ever was rung, emphasizing this contradiction by the statement that he had been shop-walker in the same business for ten years and had never heard it rung, nor did he know anyone else who had.

And yet the bell had been rung regularly for five minutes every day at 1 p.m., and I may mention that it is still rung daily at that hour, and may be heard by anyone in the churchyard who will pause and listen with sufficient attention.

Before considering the giant's voice, however, some idea should be gained of the giant himself. Though he measures no less than 9 feet 6 inches at the mouth, yet hanging as he does alone in one of the roomy chambers of the massive tower, it is difficult at first sight to get a true idea of scale, and it may require a few facts to bring home what a mighty mass of sonorous metal is there. I had the opportunity of visiting the spot where the infant was born and exhumed at the foundry of Messrs. Taylor, of Loughborough, shortly after the bell had been removed, and I looked down on a huge pit, above which, in addition to the ordinary smelting furnaces, three extra large furnaces had been constructed to provide a sufficiency of molten metal. From these cyclopean fires more than 17 tons of metal had flowed into the mould, and then it was a matter of the greatest anxiety and consequence to the founders to be assured that they had made a sound casting. Yet some ten days elapsed ere the terrific heat had declined sufficiently to allow the workmen to begin digging out the huge mass.

After this it was reported that the Midland Railway were somewhat shy of conveying to London a passenger 9 feet high by 10 feet broad, and weighing, all told, not less than 18 tons. But the real engineering difficulty commenced with the task of raising the bell up the perpendicular height of its tower. The appliances for this feat were provided by Woolwich Arsenal, and proved adequate for the purpose. Representatives of the Press were admitted to see the operation, and a correspondent would go and witness the bell in mid-air, and after lingering for a length of time at the spot would go home and report that all was well, but that no work had been going forward while he was present, and yet ceaselessly the bell had been mounting upwards before his eyes, only with such extreme slowness, owing to sheer weight, that the motion had been imperceptible.

It is an experience never to be forgotten to be at the ringing hour within Paul's circular chamber, and half way up the ladder, which allows him only bare room in which to swing clear. The hanging of the bell is mechanically perfect, the gudgeons working with the least possible friction in roller bearings, yet the first few pulls given with the combined strength of four practised men, impart but a slight oscillation to the pendent mass. Presently, however, the swinging grows in amplitude, and at the very first utterance the solid walls tremble. Then the monster, throwing up his mouth ever higher and higher, the roar rises to an intensity which is surely the limit of what the human tympanum can endure. At each alternate stroke the actual lip, $8\frac{3}{4}$ inches at the sound-bow, is quivering level with your ear, but a couple of feet away, and a storm of sound is round you. It is now that the peculiar vibration travelling round the circular chamber referred to in the last chapter may be observed. Placing the ear close to the wall, it will be noticed that in the interval of the crashing strokes there is a well-sustained reed-like drone, which continues to course round in contact with the surface, but which decays directly the ear retreats from the wall.

In this connection it may be further mentioned that at the Cobb at Lyme Regis, a crescent-shaped breakwater, there are acoustical effects similar to those of the Whispering Gallery of St. Paul's, but under circumstances where reflection in the ordinary sense, and as spoken of by Herschel, is impossible.

Before we had done experimenting in the Whispering Gallery it occurred to me to tap the wall smartly with a small wooden box, and from somewhere a double knock came back, closely resembling the well-known echo in "Neville's Court" of Trinity College, Cambridge, familiarly styled the "Freshman's Knocker." Almost any sound louder than a whisper will arouse a true and often multiple echo which can be heard from all points beneath the dome. The watchman, standing 200 feet below, had heard us conversing as though in stentorian tones.

Probably the most remarkable example of multiple echoes within a dome is that of the Taj at Agra, where a native, in anticipation of a couple of annas, will wail out a long high-pitched cry after the manner of his race, and the cry rings on indefinitely, dying by degrees, but apparently in the far distance, and so slowly that it is hard to say when it is finally lost.

Many other kindred acoustical effects in buildings are on record. In Gloucester Cathedral a whisper is conveyed by a gallery 75 feet across the nave. At the mouth of the well at Carisbrooke Castle, faced with smooth stone, the sound of a pin let fall into the water is distinctly heard, though the depth of the well exceeds 200 feet. The effects of a smooth facing has been yet more remarkably exemplified in the case of the Stock Exchange. Here, formerly, when the walls were of plaster, the acoustic properties were sufficiently good, but now that the plaster has been stripped and replaced by a smooth marble surface, a painful reverberation is set up which admits of no efficient cure.

Curiously enough, the Bourse at Paris appears also equally bad for speech. According to Professor Tyndall, anyone standing in the gallery hears only a confused babel, voices mixing with their echoes into a chaos of noise, out of which no intelligible utterance can emerge.

In some buildings possessing a curved ceiling of geometrical figure, effects of a terribly startling nature have been recorded, as, for instance, in the Cathedral of Girgenti, vouched for by a naval officer in 1824. It would appear here that a whisper used to be conveyed distinctly from the great western door to a spot behind the high altar, and conversely. In fact, these two spots were virtually the two foci of an ellipse, and by ill chance one had been chosen as the place of the confessional with dire consequence which need not be repeated here.

A parabolic surface should yield equally startling results, and it is stated that in a certain case where a bell was unheard at a distance, it was made distinctly audible by arranging a parabolic reflector behind it. I myself can, from personal knowledge, testify to a case where a parabolic surface was turned to account with very remarkable reality.

A century ago the church of St. Giles, Cambridge, was under the incumbency of one Professor Farish, of Magdalen College. This worthy divine was a Senior Wrangler; he was also a mechanician. As to whether he was a powerful preacher or not I am unable to say, but I can give proof that he strove to make his preaching more powerful by means of his mechanical ability. He designed a sounding board on strict scientific principles. Its form was that of a paraboloid, and it was erected at the back of his pulpit so that its axis was directed along the length of the church, while in its focus would be the head of the occupant of the pulpit. Thus this large hollow reflector of sound served truly to gather the preacher's words, and direct them straight against the ears of the congregation.

It fell to my own lot, a quarter of a century ago, to occupy that pulpit on one sultry afternoon which I shall not forget. I can say nothing of how I may have influenced my auditors, but I know that they affected myself inconceivably, and this for a very obvious reason. For it would seem as if the ingenious inventor of the sounding board had forgotten that it would inevitably possess a reciprocal property, and that while it reflected his words towards his hearers the converse fact would hold good, namely, that all sound from the hearers would be gathered up and crowded into the ear of the speaker. As the congregation settled to their seats a perfect tumult of sound assailed the ear.

That structures of many kinds interfere with or modify the audibility of sounds in a remarkable manner has been matter of constant observation. The Menai Straits Bridge is suspended from main piers 576 feet apart, and has numerous cross-beams below supporting the roadway. According to Herschel, if one of the piers is struck with a hammer a multiple echo ensues which consists of a preliminary sharp and strong return from the roadway overhead, followed by a rattling from the cross-beams rapidly dying away. Then the opposite pier replies, and immediately sets up a lingering palpitation with which the echo terminates.

Any plot of ground wholly or partly surrounded with mere buildings is almost sure to possess peculiar acoustic effects. The centre of Piccadilly Circus is a case in point, provided always there is an *absence of all traffic.* It fell to my lot to be able to experiment in this spot at 3 a.m. one summer morning, when I sallied out with my daughter to take snap-shots of "Sleeping London." A quadrangle also will generally possess distinctive sound phenomena. It is related of Saunderson, the blind professor of mathematics at Cambridge, that he could tell from the reverberation of his own footsteps in precisely what part of a college court he was walking. A railway bridge over a road is another familiar example of a powerful sound-gathering structure.

In face of the foregoing facts, it becomes reasonable to suppose that the variability in the sound of a bell, already spoken of, may be due, perhaps more frequently than would be suspected, to the immediate surroundings of those places where the sound is found to be augmented, or the reverse. Granting this, however, are we any nearer explaining how the sound of a fog-horn has been lost and regained without any assignable cause across the open sea? Here at first sight it would seem as if surroundings could have nothing to do with the anomalies observed, but I am by no means sure on this point. Bells at sea are notoriously unreliable as signals. A number of experiments carried out among the different sound warnings in the Thames estuary have shown me that when the sea is at all rough, bells may carry but a very short distance indeed, so much so that a small yacht steaming almost noiselessly along, would sometimes nearly run into a bell-buoy without hearing its bell, though this was tossing wildly in a chopping sea. Then comes the question, is not the broken water the cause of the bell being unheard, not only by reason of the noise of its splashing, but also because of its bad reflecting surface?

As supporting this view, I may cite Brewster's account of an officer's observation during the war with America. "When the British and American forces," he writes, "were encamped, and the outposts were so near that the forms of individuals could be easily distinguished, an American drummer made his appearance and began to beat his drum, but though the motion of his arms was distinctly seen, not a single sound reached the ear of the observer. A coating of snow that had newly fallen upon the ground and the thickness of the atmosphere had conspired to obstruct the sound."

That "thickness of atmosphere" could have obstructed sound would be strenuously denied by modern physicists; but, on the other hand, a sufficient explanation might certainly lie in the fact that the surface of the ground was loosely covered with freshly fallen snow. Unquestionably, a smooth surface between a source of sound and an observer greatly aids the intensity of the sound, just as a sheet of water lying towards the sun will greatly increase the glare of the sun; the glare becoming less, however, in proportion to the degree in which the water is agitated.

It ought to follow that a smooth hard surface such as ice should greatly aid sound, and a remarkable example of this is given by Parry in his third voyage. He writes: "Lieutenant Foster having occasion to send a man to the opposite shore of the harbour, a measured distance of 6,696 feet, or about one statute mile and two-tenths, in order to fix a meridian mark, had placed a second person half-way between to repeat his directions, but he found on trial that this precaution was unnecessary, as he could without difficulty keep up a conversation with the man at the distant station across the ice."

It will now be clear that in estimating the effect of sound not only must surrounding objects be reckoned with, but ground surface also, and perhaps even this is not all. There is still the question whether there may not also be the equivalent of a *sky-surface* to be taken into account. Arago distinctly believed in sound reflection from the sky. Tyndall likewise held modified views of the same nature. Both observers basing their arguments on the reverberation of cannon-shot, a matter on which I shall have a word to say.

CHAPTER XI

THE UPPER AIR

I SHOULD, however, first clear the ground by giving observations of conditions that may be capable of producing anything of the nature of sky-surfaces.

Flat-bottomed clouds are not infrequently met with in balloon voyages. Glaisher speaks of them in one of his earliest ascents. The clouds which were actually drifting with a north wind were sweeping across an easterly current which uniformly smoothed off the under surface of the clouds. I have noticed this as a very common effect of an east wind, and there can be little doubt that it is due to the peculiar drying effect of such a wind. At the same time, it would tend to prove—what will gain further proof hereafter — that air currents at different heights may maintain level surfaces of demarcation sharply defined.

Exceptional opportunities of determining this have occurred to observers other than aeronauts. In his travels among the Andes, Mr. Whymper describes a series of eruptions of steam from a volcanic mountain named Shangai. The cone of the volcano was about level with his place of observation and distant some forty miles. At intervals of from twenty to thirty minutes a nearly invisible jet of steam was shot upwards to a height of about 6,000 feet, when it spread out into a steam cloud which drifted with a north wind for some ten or twelve miles without losing its characteristic shape. This shape, though heaped above, was always flattened on the under surface as often as the eruption occurred. In this there was proof of a steady wind blowing continuously at a definite height, and having its lower surface levelled against the lower stratum of atmosphere over which it swept.

The converse of this observation is given by another mountaineer, Captain Basil Hall, on Teneriffe. After ascending the peak for some hours in drenching rain, he emerged at last above the cloud layer, whose surface bore the appearance of a country covered with snow—a condition of things which was wholly unchanged at the end of a sojourn of twenty-four hours.

But the levelling of cloud surface is to be constantly noticed at home at much lower altitudes and under conditions of little or no wind.

Under such circumstances, when a general mass of clear air is growing gradually cooler under radiation, at some definite height—perhaps not greater than a quarter of a mile—a stratum reaches the dew point and at once a level bed of stratus cloud is formed.

In the foregoing cases, surfaces of air of a different character have been betrayed by actual cloud, but it will need no pointing out that such level surfaces may, and probably often do, exist overhead without visible token. There is a saying among men of the coast-guard service that in an east wind sounds will be heard more clearly and that "they seem to come high." This might be accounted for by the fact stated above that an east wind levels the under surface of clouds and that off such surface sounds can be reflected.

Clearly a very important enquiry connected with the work I had embarked on would be that relating to the states of atmosphere under varying circumstances. Not only might low-lying strata of air of different densities have an influence on the travel of sound, but so also would strongly marked currents whether upward or downward.

A most instructive and much quoted observation of Humboldt's may bear re-telling here. During a stay of some days in the neighbourhood of the cataracts of Orinoco he had been struck by the fact that the roar of the rushing torrent sounded three times louder by night than by day. He argued that this phenomenon could not be due to a greater repose of nature by night in such a solitude, for in those parts the buzz of insects is louder at night, and the breeze never rises till after sunset. He therefore ascribed the effect to ascending currents of warm air, which, "producing an unequal density of the elastic medium, obstruct the propagation of sound by displacing its waves; causes which cease after the nocturnal cooling of the earth's surface."

Upward or downward currents must, of course, frequently occur and are often made patent to the eye in daytime. A wind striking the sloping side of a hill is seen by the drifting of light bodies to ascend the slope and often to descend again on the lee side. In like manner a sea breeze striking a bluff continuous cliff will, from the necessity of finding some passage, be discovered to be diverted vertically upwards.

The fine weather clouds that form overhead and float away are evidence of ascending vapour-laden air. The old saying that "the clouds seek the hills," is but a popular way of stating the fact that warmer air rising off the valleys becomes condensed over the cold high ground. A cloud will often be seen clinging for hours to a mountain top though wasting away every moment in the wind—a clear proof that there is under these circumstances a continuous upward supply of warmer air rising from the valleys and so constantly feeding the withering cloud. A similar phenomenon may sometimes be seen without the intervention of hills. M. Flammarion, describing a balloon voyage from Paris into Prussia, writes: "When we came over the largest of the clouds we found that it was situated some 200 to 300 feet above a pond. It was completely isolated, and might have been some 330 feet wide and 70 feet thick. But what struck us most was its absolute stillness. Was there no breeze blowing along the ground? Or did the wind take the form of a cloud as it passed over the pond of water? This we were not able to decide. Other small clouds were seen in like manner along the course of a rivulet. It is difficult to believe that whilst we were progressing at the rate of 36 feet per second at an elevation of only 1,640 feet there could be no breeze whatever along the surface of the ground." In this case the cloud was undoubtedly being constantly dissipated and again reformed by mist rising on air streams from below.

Any observations that would tend to throw light on the behaviour of aerial currents during the hours of darkness and night should add to our chance of interpreting not only vagaries of sound, but possibly also other mysteries, and in this there was fresh scope for the work of the balloon.

In the autumn, therefore, of 1898, at the conclusion of a series of ascents, several of which have been already alluded to, I determined on making a night voyage, which should be continued as long as circumstances would admit, and in this project I was aided by the courtesy and liberality of the *Daily Chronicle.* It was accordingly arranged that I should make an ascent on the first favourable opportunity about the time of the harvest moon. This date appearing particularly suitable, first, on account of the favourable weather often prevailing about the time of the autumnal equinox; and secondly, because we should then have the advantage of a strong moonlight throughout the night.

Michaelmastide is often a noteworthy period. It is a date around which, as Jefferies says, events seem to group themselves, and when "all the seasons are represented together in about the space of a fortnight." As in previous work my first care was to hunt up results of importance gathered by former observers. Several night ascents are on record, but in comparatively few of them have observations been made of any scientific value. M. Flammarion has made an interesting note respecting a night voyage in France during which he passed over several peat bogs and morasses. It appears that repeatedly while at an elevation of from 3,000 to 4,000 feet he distinctly heard the croaking of a multitude of frogs, and was led to argue that the clearness of sound may have been due to the fact that the temperature of the atmosphere was more uniform than that in day hours.

Mr. Glaisher, on the other hand, has supplied data from which this uniformity or the reverse may be more accurately inferred. On one occasion this indefatigable aeronaut, in fine warm May weather, arranged a double ascent, in which his purpose was to start at a certain time before sunset; to rise steadily to a definite height, then to descend again gradually in such a manner that he might return to the neighbourhood of earth as nearly as possible at the moment of sunset, after which he should reascend as before, reaching the same altitude and occupying the same interval of time. Careful and continuous readings of temperature made throughout the entire double ascent would, Mr. Glaisher hoped, lead to valuable and novel results, and in this expectation he was, as will be seen, fully justified.

It was on the 29th of May that the experiment was carried out. On that day the sun set at 8 p.m., and at 6.15, under the guidance of Mr. Westcar, of the Royal Horse Guards, the first ascent commenced at Windsor. The temperature, which read 58° on the earth fell only 3° in the first 1,200 feet, but had fallen another 12° in the next 2,400 feet, when it remained fairly constant while the balloon rose through another 1,000 feet. Then, however, the air grew steadily colder with increasing altitude, and at 3,200 feet the thermometers read 29½°. It was now 7.17, and duly to carry out the proposed programme the descent was forthwith commenced, when it was found that though the air at once began and continued to grow warmer it did so in an irregular and uncertain manner. On reaching the neighbourhood of earth they were nine minutes behind time, and the sun was theoretically already set, the temperature being 54°, or 3° less than it was at the first start from the ground. Mr. Westcar at this time found some little difficulty in the management of his balloon, which on passing over the ridge of a hill appeared to be sucked down towards the earth; so that to save coming to ground he cast out a large quantity of sand, with the result that the balloon recovering shot upward again with speed, to some extent spoiling the experiment, for whereas in the former ascent the height of 6,200 feet had been reached leisurely in rather more than an hour, now the same height was climbed abruptly in scarcely more than ten minutes, and this rapid ascent would be too fast to allow of such instruments as were then in use giving reliable readings; for sufficient time must always be allowed for a thermometer, however sensitive to adapt itself to the surrounding temperature, and if such sufficient time is not allowed then the instrument will be sure to show some lag—reading under normal conditions too high in ascents and too low in descents. However, after a pause of a few minutes it was conclusively shown that the temperature of 6,200 feet was at the hour of 8.20, or twenty minutes after sunset, some 6° warmer than it had been three-quarters of an hour before sunset. This was undoubtedly the most important result obtained during the highly interesting voyage.

On another occasion Mr. Glaisher pushed his investigations further into night hours, but before dealing with his results, two points in the voyage last recounted claim attention. In the descent which preceded sunset, and which was conducted in a steady and leisurely manner, the warmth was found to increase, but in a way which was far from regular. In actual fact, though the approach to earth was gradual the temperature rose fitfully, as by sudden accessions, as though volumes of warmer and cooler air were getting mixed up in some confusion. In other words, the warmer air, which was presently found to have risen aloft, was breaking away upwards in separate invisible clouds, and while this was taking place it must follow, as a matter of course, that the colder air from above must be settling down towards earth; and there is proof of this in the peculiar incident which Mr. Glaisher recorded, namely, that the balloon was sucked down to earth on passing over the ridge of a hill. This descent of air down a hill-side after the heat of the day is common and intelligible enough. If a large bell glass be placed over a piece of smouldering paper on the table the warm smoke rises in a central column, and, getting chilled, descends again, creeping down the cold glass sides. The same process takes place in a sitting-room, which is closed for the evening, with lamps lit. Warm air, and none too well suited for respiration, rises in volumes to the ceiling, as anyone may discover who, with the aid of steps, endeavours to hang a picture late at night, and pours down again in contact with the cold walls. This downward current being sometimes so strongly marked as to give rise to the belief that "draught will come through a solid wall."

On a still larger scale the same process holds good in the open air under a cold sky. The warm air radiated off the surface of earth, heated through the day, will give place to colder air descending hill-sides, or, indeed, filtering down where it may between the warmer rising masses.

And a moment's thought will show that from off diversified country warm air must be rising very irregularly after the sun has set. Some tracts of land will have absorbed much more heat than others during the day, while some will part with their heat through the night much more readily than others. Thus roadways and brown-baked plough land or fallows will long continue to give off the stores of heat that the day's sun has imparted to the earth.

On the other hand, ground that is clothed with green crops or herbage will lose but little heat, because, though green leaves and blades of grass quickly part with their own warmth, they are bad conductors of the warmth of the ground beneath. This is made patent enough by the copious deposition of dew on grass and foliage under a clear night sky.

It was under a clear night sky, at the commencement of the month of October, that Mr. Glaisher made an ascent from Woolwich Arsenal. The sun had set for three-quarters of an hour, but the moon was shining brightly and the sky was cloudless. On the ground the thermometers read 56°, and 1° higher when at an altitude of 900 feet, but there was an increase of temperature of nearly twice as much in the next 300 feet only. Mr. Glaisher then commenced a series of zig-zags in the sky, mounting and dropping repeatedly chiefly within the limits given above, thus making sure of his results and establishing the fact that the temperature invariably increased with elevation and decreased with descent, the highest temperature on every occasion being met with at the highest point. This result, in his own words, "was remarkable indeed." With characteristic thoroughness he next determines and discusses the change that was found to take place in humidity, which certainly was equally remarkable.

Adopting the usual convention, 100 was taken to represent the hygrometric reading of air which is saturated with moisture. In Woolwich Arsenal, then, at the start the humidity read as 95, while at the same moment, four miles away, at the Royal Observatory, Greenwich, the humidity registered only 84. But from this moment things went by contraries, and some two hours afterwards, when at Greenwich the moisture in the air had risen to 97, in the car of the balloon it had fallen to 85, or in other words, the water in the air had fallen. Here an important note is added, namely, that in spite of great clearness of sky, extremely little loss of heat by radiation was going on.

This being the physical condition of the night sky through which the all-observant aeronaut was sailing, his brief account of what he saw and heard, ere he reached earth in Oxfordshire, is full of interest. The first sight that claimed his attention was, of course, the crowded and far-reaching outskirts of London now illumined by a million lights. Woolwich, Blackwall, Deptford, Greenwich, despite their squalid streets and miles of river mud, formed a starry spectacle exceeding in brilliancy anything the narrator had ever seen. And for this reason chiefly, that whereas London, viewed from a balloon at night, had always appeared something like a vast distant conflagration, on this night the air was so clear and free from haze that each and every light was distinct, and they seemed all but touching each other. Half an hour later the balloon had drifted so that Oxford Street lay underneath, and here the roadway looked dark, while either pavement, reflecting the brilliant illumination of the shop fronts, shone like frosted silver. At this time, too, and until Paddington and the Harrow Road were left behind, the moon, though shining, "seemed to give no light," and it was only when the more open country was reached that the earth came into view, and the fields and the balloon's shadow coursing through them. It was at this point of the voyage, or when the travellers were passing over the Middlesex suburbs in the direction of Uxbridge, that Mr. Glaisher adds what is to me an important memorandum. He says "not a sound reached the ear; the roar of London was entirely lost." Yet the busy town was but a few miles away to the windward, and as yet it was not eight o'clock!

Summarising Mr. Glaisher's results from this aerial voyage, we get a very remarkable collection of facts. It is a clear moonlight night in early autumn—exceptionally clear, so much so that even the haze constantly noticed over London is absent. Yet for all this, at moderate altitudes the radiation of heat into the open sky is going on comparatively slowly, while in those regions the moisture in the air as the night wears on becomes continually less, draining down, in fact, towards the earth. But to set against this, or may be to account for it, is the fact that the air at all heights where investigations were made was found consistently growing warmer. In other words, warm air was everywhere ascending off the earth, while the colder and moister air was settling downwards.

That the moon's light reflected off the earth should have been quenched by the stronger illumination of the London streets does not appear to me hard to understand; but the singular silence observed, the rapid fading out of the entire babel of London, claims every attention, and this was a point on which I hoped my own night ascent would throw some additional light.

CHAPTER XII

A NIGHT ON A CHURCH TOWER

BUT first some little preliminary work seemed desirable, some testing of instruments, and a dress rehearsal of some kind, if this could be accomplished. My observations would practically be the same as Mr. Glaisher's, but he speaks in his narrative of the difficulty of taking observations readily by lamp-light. It would be well, therefore, I foresaw, to have practice in the making of night readings, and to note how the instruments I was to use would behave on the ground through some fine night as near the date of my ascent as possible. It occurred to me further that I might do better still by organising a rehearsal, not actually on the ground, but from some isolated and elevated situation, and an admirable spot for the purpose presented itself in the top of the neighbouring church tower of Thatcham. Gaining the ready co-operation of the courteous and friendly vicar, arrangements were made that would allow of my having free access to the tower at any hour, and a favourable night shortly occurring, a little after eleven o'clock a start was made for the church, distant some two miles across the valley.

As able assistants, and used to my own methods, I had with me my son and daughter, who have aided me in many a scientific quest alike above the clouds and in eclipse and other expeditions in all quarters of the globe.

There was a conscious, almost guilty, feeling among us as we sallied out that night into the quiet lanes with a kit consisting of strange-looking instruments, a portentous marine ear trumpet, and a dark lantern. Had we been unknown it might have been difficult to satisfy the scruples of any rural policeman we might meet, particularly if we confessed that our goal was a lonely village church. A sufficiently substantial meal, it may be mentioned, might also have been found secreted in our baskets.

Thatcham Church has stood in its quiet little churchyard since Norman times, as its history and architecture alike testify. It is situated at the south-west corner of the village, and practically isolated from houses. Its massive square tower, whose height is 80 feet to the parapet, is entered from without by a small belfry door, and climbed through half its height by a stone stairway built in the wall; after which, crazy ladders lead up past the ringing and clock chambers into the loft where hang the ponderous grim old bells. Thence, by a more difficult scramble, the trap-door in the roof is reached, which admits the climber on to the open leads above, shielded only by the low battlements.

This ascent, none too easy when essayed for the first time by the light of a dim lantern, we had won up to the point of reaching the bells; but here, among the monsters, in cramped quarters, with their clumsy wheels and framing, encumbered as we were with baggage, we managed to get ourselves inextricably wedged in, when our light went out, and left us in total darkness. This accident imported some little spice of adventure into our exploit, for to be imprisoned up among lonely jackdaw roosts through a long, dark night, seemed for the moment quite a possibility if we failed to re-establish a light. Before we could attempt to do this, there was a noise as of something giving way at our feet, a loud thump, and then a whirring sound in the chamber below. The noises broke the dead silence of our retreat in a singularly abrupt and startling manner, and it was, perhaps, well that we at once grasped their meaning, for we simply held fast and waited the issue. For a few seconds there was an uncanny trembling of timbers beneath us, followed by a crashing double stroke on two of the bells right and left of us. This was repeated four times, followed by a short pause, when from the opposite corner came the big voice of the tenor, deafening us with its clamour.

This, then, was the way in which the old tower has told out its midnight message every night these two hundred years. Could the old folks who are sleeping in their grassy tents outside return to life, they would, among all else that has surely changed, hear these old familiar voices alone unaltered.

The last reverberations had scarcely died away, when another and different noise fell on our ear, an echoing sound below us, a footfall on the stone steps far down. Then a tread on the wooden ladders, and other evidences of someone mounting the belfry, and well familiar with the way without a light, and heedless of the pitchy darkness. We were before our time, and this was, undoubtedly, the custodian of the tower hurrying up to get matters arranged for us. Seeing no light, he would feel sure that we had not arrived, and, as we remained motionless in the darkness, he was presently standing among us without having the smallest suspicion of our presence. Then, jammed in as I was somewhere between the bells, I called to him:

"Is that you, Thomas?"

I doubt if Thomas ever pulled up shorter in his life, and I learned that it is possible even for an old bellringer to be taken aback in his own belfry. Thomas and I have rung many a touch on the handbells together on winter nights, and with his friendly assistance, we and our instruments were quickly transferred on to the roof above, and we were left to pursue our observations throughout the night.

One solitary light could be seen in an upper window of a house a quarter of a mile away, but after a short while this was extinguished, and from that time no sight or sound could be detected from our watch-tower that told of life around us. The night was still, and, beyond perhaps the occasional cry of the owl, there was no sound in the air, always excepting the leisured, muffled throb of the tower clock, and the challenge of the bells as each quarter passed.

Our first memorandum relates to the moon, which now, some nine days old, was hovering near her setting over the faint outline of the Hampshire hills. Her gibbous body, looking strangely large, shone dimly with a dull red, almost copper hue, and this pointed to the presence of a large quantity of matter floating in the air at low levels. This universally accepted indication admits of ready explanation, for white light consisting of rays of all wave lengths, it is clear that it will be the smaller waves, *i.e.*, those belonging to the violet end of the spectrum, which will meet with most opposition where minute obstacles lie in the way, while the larger waves, orange and red, suffering less hindrance, will preponderate. In other words, the light from either sun or moon, when these are near their setting, having to pass through greater range of low-lying strata, will become more shorn of blue and blue-green rays, and hence appear more ruddy, according as there is more matter hanging in the lower atmosphere. This is particularly so in or near large smoky towns. In the pure air of the country, however, on the night of our observation, there was certainly an absence of all smoke, and hence we were possessed of clearest proof that particles of moisture or dust, or both, were lying in large proportion at a height exceeding that at which we were stationed. This memorandum, as will be seen, possessed a certain value a few nights later.

The story told by our meteorological instruments during the few hours of our vigil can be soon stated. The moisture in the air, which was not above the average, remained fairly constant, but the temperature, when properly measured, declined considerably and consistently. It may be well to state here that a thermometer left to itself might have given no reliable indication of the night air. It would certainly have told different tales, according as it was placed on the stone parapet, or on the leaden roof of the tower, or on the grass at the tower's foot. The conducting or radiating properties of its surroundings would have made a noticeable difference in its behaviour. This fact, until the introduction of freezing machines, used to be turned to practical account in India in the production of ice.

Shallow porous vessels containing water were placed in hollows which had been dug in the open ground, and filled in again with loose, dry rice-straw to within a few inches of the surface. This straw serving to prevent the access of heat from the ground below, the water would become frozen by the copious radiation of its heat into the clear night sky.

The best, if not the only, reliable method of testing the temperature of the air, is by means of a "sling" thermometer. This is simply a thermometer tube, bearing graduations, and having a string attached to one end, but divested of any other mounting soever. As often as an observation is required, it is merely necessary to whirl the slender tube round a few times by means of the string, when, its surface being everywhere brought into contact with rapidly circulating air, a correct reading is quickly obtained. Wherever, in my own observations, atmospheric temperatures are given, it should be understood that this method has been adopted.

Having secured accurate indications of all essential conditions of atmosphere, possessing also the rare opportunity of having a perfectly tranquil night, with as near an approach to absolute silence as could probably ever be obtained in the open, and near the earth, I proceeded to make such observations on sound as would compare with results obtained by myself and others in the profound and perfect silence of those upper regions which are visited only by the aeronaut.

An experiment I had constantly tried from a balloon, was to lower a loud-ticking Waterbury watch by a string over the edge of the car, and note the distance at which it remained audible. This distance I had found a variable quantity, depending—if the testimony of one's ears can always be trusted in dealing with sounds at the limit of audibility—mainly on humidity and density. On the present occasion it was quite evident that the hearing over the edge of the parapet was superior to any I had recorded in upper regions, and a sufficient reason for this soon became apparent, and is worthy of careful consideration.

It is often asserted that "sounds ascend more readily than they descend," and in a general way I am prepared to admit the statement. Again, Professor Tyndall asserts that if two cannon were to be charged equally, and one fired at Chamouni and the other at the top of Mont Blanc, then the one fired below may be heard above, while the one fired above is unheard below. Here, again, I doubt not that this is only a statement of fact. But when the Professor asserts that this is so "because the intensity of a sound depends on the density of the air in which the sound is generated, and not on that of the air in which it is heard," I am only astonished that he has gone so much further than is necessary to seek an explanation. In simple fact, the difference in the intensity of the sound would mainly depend on their background. The voice of a singer is heard very much louder in a hall than out of doors. A shout or a crack of a whip is much louder in a street than in the open; the noise of a train is heard very much louder by the passengers when they are passing under a bridge or even between low walls. The explanation in each of these cases is the fact that the sounds are redoubled off some background. It would be so with the gun at Chamouni. It is also often so with other sounds that ascend, and undoubtedly it was also so in the case I have just cited on Thatcham Tower.

When, however, the watch was placed inside a deep paraboloidal cup which formed its only true background, and which was then directed towards the listener, in this case it was found that no difference could be detected in the intensity of the tick, whether it travelled from ground to parapet or from parapet to ground. A further proof of how greatly the intensity of sound is affected by background was given in this way. A listener armed with an ear-trumpet remained on the tower while the watch was noiselessly carried from the foot of the tower to a distance along the ground. It was found in this case that the watch sounded fainter and fainter until it reached the neighbourhood of some large leafy trees, when the foliage acting as background, the sound became augmented.

Late on in the night my daughter had descended to the bell chamber to arrange a flash-light picture of the bells, when she presently called out that a train was approaching down the branch Great Western line, and then and not till then from the open roof above the rumble was detected coming in the far distance. Ere the train had passed us we had proved beyond question that its sound was more audible among the bells than on the open tower. Yet the bell chamber possesses only four openings, each shielded with the ordinary wooden lattice.

We had proof here of a fact to which I had before drawn attention, namely, that instead of going to the window to listen to some sound without, it will often be found better to open the casement and to retire back into the room.

CHAPTER XIII

A MIDNIGHT ASCENT

Four days later occurred an event to which I had keenly looked forward, and which will always be memorable in my aeronautical annals. This was the occasion of my first night ascent, and all things combined to render it one of peculiar interest. The moon was nearly full, and at the hour of our ascent, 9.30 p.m., was within one and a half hours of her southing, at which time she was surrounded by an iridescent ring. The sky, however, was clear, and the night, as regarded from the Crystal Palace grounds, perfectly serene and calm. At the hour of sundown, when I was speeding through Ealing in the up express, I entered in my note-book, "Sky clear and frosty; ruddy yellow sunset; few clouds; low-lying packs and streaks; nearly calm; wind has veered from S.W. to N.W." Thus in four hours the night had grown clearer and stiller, with every prospect of its continuing fair. The date was September 28, four days earlier in the year than Mr. Glaisher's night ascent last related, but our start being some hours later than his, our thermometer on the ground read 49° as against his 56°. The air in our case was considerably drier, but Mr. Glaisher's experiences were entirely confirmed in that the humidity decreased as we ascended and as the night wore on, showing that, as Mr. Glaisher himself put it, "the water in the air was falling."

Besides my friend Mr. Percival Spencer, the aeronaut, there sailed with us that night Mr. Swinbourne, who was indeed making his first trip in a balloon, but whose world-wide experiences and exploits as a war correspondent are well known, and as I have now so often described my own sensations in balloon travel, it will be refreshing and instructive to read a few words of the narrative which so experienced a traveller as Mr. Swinbourne contributed to the *Daily Chronicle*:—

"At half-past nine to the moment, with a hearty cheer from the little crowd of on-lookers, the balloon was freed, and in a minute or so we were at a height of 650 feet, and finding ourselves, curiously enough, considerably warmer than we had been on *terra firma*. Away behind us lay London, lanes and lanes of sparkling light; but to make out special localities was not easy, although we could readily distinguish the flash-light of the Belvedere Tower at the Earl's Court Exhibition. At 1,000 feet high we were over some suburban railway station, and the sight of a train rushing along a curved cutting was one not to be forgotten. It was like a comet with a fiery gold head and a silver tail. The moonlight on the trail of smoke made it look like the rapids of a river in moonlight. A rushing mass of silver water; the engine was a glow of fiery red. You saw no train. . . . At 2,000 feet it was marvellous to note the clean cut shadow of the balloon which the moon gave. As we threw out sand, its shadow could be seen dropping from the balloon, first in a broad stream, then as it disintegrated and the particles separated, widening into a nebulous shade, to disappear altogether as it dropped earthwards. Both the experienced aeronauts who so kindly permitted me to accompany them, assured me that the balloon's shadow thrown was far more distinct and sharply defined than during voyages by day. The night, in truth, was a perfect one, and I have never known what moonlight can be till last night. Every roadway, hedge, and rivulet, stood out as clear as if we were looking down on a large scale map. . . . . At 2,500 feet we were moving very slowly, as one could tell by watching the trail rope, the time then being a few minutes to eleven, and at this moment we passed one of the most striking of the many picturesque effects the night had afforded us, as we crossed the Medway right over the Pottery Works at Aylesford. The blazing furnaces gleaming below, encircled by the tortuous silvery winding of the river, offered a superb *coup d'œil* under the moonlight."

In truth, the neighbourhood of the Medway afforded us occasionally a wonderful spectacle, for over its windings everywhere, in spite of the perfectly clear air elsewhere, was piled a deep and wide bank of mist, white and still; and though we knew our course sufficiently well to be sure that we were far inland, yet it was many times almost impossible to resist the conviction that, sometimes in one quarter, sometimes in another, sometimes almost enveloping us and always near at hand, there, under the moonlight, was the wide sea into which we were infallibly drifting. This curious phenomenon of a sea of mist in an otherwise clear sky, extending high into the atmosphere and marking out a river's course throughout all its length, has not unfrequently been mentioned by aeronauts. To quote one example, in an ascent made on September 1, Mr. Glaisher writes: "At 5.30, when we were about 4,000 feet high, clouds were observed forming and following the whole course of the Thames from the Nore up to the higher parts, and extending but little beyond its sides. The clouds were parallel to the river, following all its windings and bendings."

When at length increasing our altitude and sailing out over the heart of Kent we escaped from all proximity to Thames or Medway, the view over the vast stretch of country below us was astonishingly clear and apparently limitless in extent. The well-known country over which I had so often soared in daylight hours was all unfamiliar now, bathed in moonlight. The usual landmarks were shrouded or disguised, and the faint horizon, which really was not so very distant, seemed fully fifty miles away. But here and there over the wide country could be seen a shimmer in the skies telling where quiet towns were sleeping, and in this night-glare each town stood confessed. Over some hovered a brilliant glow, pure and white, indicating that the source of illumination was electric light. Elsewhere a lurid glare showed that the light was due to the combustion of that product which is dear indeed to the aeronaut, but deservedly dropping out of favour as an illuminant. From one town, imagined, but possibly quite erroneously, to be Chatham, a dense smoky cloud was continually forming and drifting away.

But our story, from the observational side, has yet to be told. From what has been already said it will be understood that even the best designed thermometer mounted in wood or other material, or enclosed in a case, however well ventilated, is ill adapted to record the temperature readings of air that change from moment to moment. On the other hand, it would be inconvenient, if not impossible, to be constantly using such a contrivance as the "sling" which I have described. To meet this difficulty, I was on this occasion provided with an exquisitely sensitive air thermometer, the essential advantage of which consists in a very large bulb made of very thin glass. This bulb contains air, but opens into a narrow, straight glass tube, which is filled up to a certain height with a coloured liquid and connected with a cistern of the same liquid at its further end. Owing to the large surface of the bulb and its extreme thinness, the smallest alteration in external temperature almost instantly affects the imprisoned air, which, by shrinking or expanding, alters the level of the liquid within the tube and so records either a fall or rise of temperature. On leaving the earth, I had this instrument slung in the free air in front of me, and scarcely removed my eyes from it for the first half-hour, and in this I was well rewarded. It being an early hour of the night, I was expecting from the experience of others to rise into regions that had been growing warmer, but instead of finding a regular or consistent rise of temperature as we climbed the sky the delicate instrument showed constant and sudden fluctuation.

The temperature rose one degree with the first 700 feet, and another degree with the next 300 feet, then as we shot up to 3,000 feet it dropped one degree, falling yet more, however, as we began to descend. But between these particular readings were constant variations, sometimes of rise and sometimes of fall.

On the whole it was clear that, speaking broadly, temperature for the first part of our voyage varied with altitude, but the rise or fall was no more uniform than is the ebb or flow of the tide upon the beach;

indeed, just as the advance of each wave upon the shore is infallibly followed by its recoil, so would any decided rise in the glass give place presently to a corresponding fall.

It was, of course, by no means proved that this fluctuation would have been so noticeable, if noticed at all, had we ascended in a strictly vertical direction. In this case we should have been driven to the conclusion that pools and patches of warmer air rested in mid-air at different levels, something in the same way as different strata of cloud are seen piled above each other in a chequered sky. This may have been so, but when we consider that the balloon, whether rising or falling, was all the time travelling in a lateral direction, it is quite clear that the fluctuations recorded may have been due partly or entirely to ascending currents of varying temperature rising off the different tracts of country over which we passed.

Another series of records threw a side-light on those just considered. A number of exactly similar exposures were made during the voyage by a camera holding sensitive films, the camera being in each case elevated at the same angle and always directed towards the opposite quarter of the heavens to that in which the moon was shining. To the eye the sky remained uniformly clear and bright throughout, and it might have been supposed that photographic action on films would have depended simply on the altitude of the balloon or the height of the moon in the heavens.

This, however, was not the case, and the experiment went to show that the photographic action of the sky varied to some extent with locality, as though the air over different regions differed intrinsically in its transmission of actinic rays.

All the while the moon herself was claiming close attention. I have mentioned that viewed from earth she was girt with coloured rings. These, however, entirely vanished before we had reached an altitude of 3,000 feet, and were not seen again until our descent, when they appeared more pronounced than ever, and so remained for the rest of the night. This fact almost necessarily led to the further fact that the moon herself increased in brilliancy, but this would be to state the case too mildly. In actual fact I have never known the moon to shine with brilliance equal to that with which she blazed down upon us when we were sailing at a height of less than a mile above the Kentish hop-gardens; and I state this confidently, although it has been my fortune through many years to make observations and drawings of the moon in nights of exceptional seeing. There was, moreover, an entire absence of that apparent quivering, technically known as "boiling." It is a fact well known to astronomers that a slight haze aids the observation of the moon in a telescope owing to its great brilliancy, but from our balloon it was simply intolerable to try and view her at all through an ordinary field glass. We were not higher at the moment above sea level than is the Lick Observatory on the top of Mount Hamilton, but I question if any mountain height is comparable as regards atmospheric conditions with the regions which a balloon may readily attain. Earth and rock surfaces on the mountain top, which have gained heat during the day, part with that heat, and so cause disturbance of the air during the night. The winds that blow against the sloping sides of the mountain must strike upwards in ascending currents, while colder air must through night hours beat downwards towards the valleys. Thus the air can scarcely be free from turmoil. Moreover, the mountain is after all part of earth, and, maybe, the atmosphere everywhere in contact with earth is grosser than where it is far removed from earth's influence.

Certain spots on the moon, for example the formation which bears the name of Aristarchus, are known to shine with peculiar brightness as though phosphorescent or composed of some more brilliantly reflective matter. An attempt was made to descry these brighter features with the naked eye from aloft, but without result.

Equally striking with the moon's light was the blue of the sky out of which it shone. It was of the deepest shade imaginable. As far back as 1804, Gay Lussac, in describing his balloon ascents, called attention to the deep Prussian blue that the sky assumes, particularly in the zenith. And this is only what might have been anticipated from considerations given in a former chapter. The far depths of the sky reflect back in some measure the light that is streaming through them, but, holding only minute particles capable of reflection, the light returned to the eye by them consists only of the smallest luminous vibrations, *i.e.*, those which belong to the blue end of the spectrum. The highest parts of the heavens being seen through shallowest depths of low-lying strata will show the purest blue, and when at lofty elevations the grosser particles floating in the lower atmosphere have been left behind, the light that the vault above them reflects may then consist only of those minute undulations which belong to the indigo and violet.

Even those who have never ventured up to lofty heights must have noticed the great differences of tint due to local conditions in the depth of perfectly cloudless skies. Thus a bright and cheerful blue attends a fair and settled season, while a duller, gloomier hue is generally a sure token of unsettled weather. Doubtless, moreover, there is a great deal to be learned even from the face of the sky that bears no clouds. There is a very instructive observation made by Nansen during his first winter in the *Fram.* It was early February, and his latitude being within the 80th parallel, the mid-day sun could not show above the horizon till a fortnight later, but there was a strong sun-glow in shades of yellow, green and light blue, while all the rest of the sky was " deep ultramarine." The temperature at the time was 47° below zero, and the learned traveller, while remarking that in his regions this deep colour always occurs with cold, suggests as a cause that a current from more northerly clear regions may produce drier and more transparent air in the upper strata. It may be confidently stated that when the moisture and other particles in the air are eliminated to the maximum degree, the capability of searching into the depths of space is increased in a manner which the ordinary observer would fail to conceive.

A pocket spectroscope, which formed part of my instrumental equipment, gave its own record, which can now be made easily intelligible. The claims of this instrument are, that whereas all ordinary forms of hygrometers or measurers of moisture can only record the degree of humidity residing in the air that immediately surrounds them, the spectroscope can sift the rays that are penetrating through all space, and among its indications can show how much invisible vapour is contained within the entire depths of our atmosphere. In other words, it is claimed that certain distinctive spectrum lines are of telluric origin only, and tell simply of aqueous vapour that would otherwise be invisible or unknown. It remains now only to state that this instrument had shown strongly marked telluric lines when used with the low moon on Thatcham Tower, but that during our midnight voyage in a higher altitude there was no indication whatever of water vapour discernible.

So far no mention has been made of acoustic experiments, though in reality these formed the principal part of the night's work. In Mr. Glaisher's account of his night voyage over London, it will be remembered that he is struck with the rapid fading out of sounds; the roar of London being quickly lost to him as he passed over the suburbs. On the other hand, the observations made in the church tower only four days before our present voyage showed that the lower air on that night was eminently transparent to sound. I had determined not to trust to the mere tale told by sounds from earth, seeing that our journey would be a late one, and our most probable direction being to the right of Bromley and Chislehurst we should travel over a district that should be quiet enough in midnight hours. I therefore determined to confine observations entirely to those that could be made by echoes from off the earth's surface, and in my experience this has proved a most serviceable method. With a suitable horn it is easy after a little practice to produce not only the same note but the same volume of sound, and the interval that elapses between the blast and its return from earth is a valuable check on altitude—indeed it is, perhaps, the only true indication of actual height above the surface of the earth at any moment. It is obvious that an aneroid can only tell height above sea level, while any true estimate of either heights or depressions in the land immediately beneath a balloon is practically out of the question.

I have mentioned in former trials which had been confined to hours of daytime that the inferior limit of the echo had been 1,000 feet, while the maximum distance was 2,500 feet, so greatly had different days differed in audibility. I was now, however, to find that there might be great variation in hearing during a single night, or at least during the early half of the night.

When we had risen 1,000 feet I used the horn for the first time, but got no response in spite of my repeating the blast a great many times, and though the presence of some extraneous sound in the air may partly have accounted for this, I am convinced that the hearing was peculiarly bad. Presently, on travelling further afield, and when we had risen another 200 feet, I caught the first echoes, every time distinctly yet very much subdued. But twenty minutes later, though we had then exactly doubled our height and were riding at 2,400 feet above sea level, the echoes came back after a protracted interval with far greater clearness. Twenty-five minutes later, when we had dropped 200 feet, they had somewhat faded, and once again, when at 2,000 feet, they had vanished entirely. Though I might challenge the earth again and again it would vouchsafe no answer, and in all these experiments it must be borne in mind that a sufficient number of trials were always made and after sufficient intervals to ensure our passing over all varieties of earth below, thus avoiding the falsification of results from the accidents of any unusually bad or unusually good reflective surface. It will be made clear in the account of experiments which I was shortly to make under special advantages, that circumstances of homogeneity and humidity may affect the travel of sound far more powerfully than mere distance.

When our several observations had been pushed well on into the night and the small hours were upon us, we had apparently reached a period when results for the most part remained constant; we were, moreover, by this time growing uncertain of our locality inasmuch as we had not been able to gauge the rapidity of our flight (as we afterwards learned a very leisurely one), and the distance, though clearly visible, was growing with the declining moon constantly more vague and difficult to interpret. It therefore became a question whether it were not well to climb down to earth while we knew that solid ground was still beneath us. With a fair amount of good fortune we might yet find a lodging, and possibly a couple of hours' sleep before the morning. Somehow, too, we allowed ourselves to be deluded with the feeling that even if the hospitality of a friendly roof could not be procured, a straw stack, a barn, or even the lee side of a leafy hedge would be sufficient for our wants.

For we were at the time revelling in an atmosphere which if not actually warm was at least genial and pleasant, and, as always in a free balloon, we were quite unconscious of the presence of any wind. We had, in fact, forgotten the lesson which our own records had taught us, namely, that the usual temperature of the earth and that of our present region had been changing places. But the fact was soon to be impressed upon us in a very palpable manner.

The balloon was already settling earthwards of its own accord, and as the country seemed fairly open and cleared of crops we simply liberated a small amount of gas and waited for developments. Slowly and without acceleration the earth rose towards us, fields expanded, and trees grew larger, and presently we crossed a roadway at a height of about 300 feet and then hovered over a stubble field beyond. We were at the time explaining to our new companion the nature and occasional exigencies of a descent, bidding him bend his knees and be ready for a bump; but the bump did not come. Then we bade him be prepared for a brush through the trees at the end of the field, but the trees drew no nearer, so that we thought our direction must have changed, and then we thought the wind had lulled entirely, for we did not seem to move at all, and not for some minutes did we discover that our trail rope had caught in telegraph wires by the roadside and we were already fairly moored.

It was the quietest ending I can recall. We simply pulled ourselves down hand over hand, and when within a few feet of the earth a dusky figure broke through the hedge and came up running as for dear life. He was a gamekeeper, and had pursued us across country for more than a mile. He had hardly explained this between gasps when there was another crash in the hedge, and this time a burly policeman on night duty bore down and claimed his right to know what was in the wind.

Two more efficient or willing helpers—and there clearly were no others at that hour in all the country side—could not have been found. From them we learned that the nearest habitation was a lone public-house one and a half miles distant. But ours was such a monster craft, and when they learned that as a cart-load it weighed half a ton, they declared our inability to convey it so far. But as yet they knew not of balloons. Carefully Mr. Spencer paid out ballast till the balloon was just poised with our three selves still inside. Then he gave instructions to our two friends to bear a hand on either side of the car, followed by the words, "Left about, march!"

To their infinite astonishment and delight the huge structure with its three passengers was forthwith borne along between them as the lightest burden. And thus we journeyed joyously over the stubble, and when we came to a hedge the gamekeeper would climb over, and the constable with a lusty effort would fairly throw the balloon over the hedge into his arms.

Yet it was not all joy. It was intensely cold and, the late excitement over, we found ourselves fairly shivering, and with good reason; for whereas ten minutes before, half a mile up in the sky, we were revelling in a benign and balmy climate, we were now on a bleak hill-side in a raw air that was little above freezing point. At the inn we found a light, but no admittance; the constable, who knew the ways of the house, felt sure he could win his way, but his most persuasive appeals met with no response. Then we applied pebbles to the upstairs window, and lastly we practised bugle calls on the hunting horn in the back yard. But the only reply was the extinguishing of the light from within, and, after all, this was not without reason, for it was the time of hops, and we were doubtless taken for belated and troublesome "pickers." When mine host discovered the next morning that a balloon during the night had been emptied and packed up in his own paddock, and that he had lost a fair reckoning, he was probably more sorry than we were. For with moonlight to help us, we accomplished our task, and having some time later succeeded in rousing a local carrier, we presently found ourselves on the high road to Maidstone, where we arrived as the clock was striking three.

Maidstone is a pleasant resting-place for travellers during recognised hours of entertainment. It is otherwise at 3 a.m. when the hop season is on. Vainly we rang and knocked at the principal hotels till our arms were tired, and our spirits flagged. At length once again a policeman came to our aid. He was sorry for us, particularly because he feared he could not help. "But, sergeant," I urged, "it is your duty to find us shelter." He shook his head. "Then," I said in despair, "if I break a window you must at least take us to the lock-up." "You wouldn't be comfortable, sir," he replied. "It is already full of drunken hop-pickers." Of course, at last he did get us lodging—at a respectable inn where there was one bed. I myself elected to occupy the easy chair in the bar, where I got an hour's doze.

Then at dawn I strolled down to the station where were a knot of porters gazing in bewilderment at a huge shapeless assignment of goods bundled down in the roadway outside without label or address. One thought it was a lot of tarpaulins; another that it was a crate of some kind.

"You're all wrong," I said, "that's a balloon. I came down in it from the skies last night."

CHAPTER XIV

"MAROONED"

When the results of the night voyage just related had been digested and duly compared with those recorded by other observers, they seemed to point to the need of further experimenting in other directions. The work I had set myself could clearly not be wholly carried out in balloons. I was as yet no nearer learning more about the "Zones of Silence," noticed by mariners at sea, and already referred to in a former chapter, and though the investigations of atmospheric conditions prevailing at all heights and at all hours should prove of great value, as also all records of the sounds that could be heard or not heard in the upper air, yet there were many questions which could only be answered by observations made actually at sea.

Unfortunately, however, the motion and noise of the waves are usually great hindrances in the way of acoustic experiments, either on cliffs or shipboard. The ideal observatory would be some island well out at sea, but on whose shores the waves should never beat. It should be somewhere near the track of vessels, where steamers plying night and day should sound their warning signals, where fogs should lie and beacon lights be shining. Further, it would be well if it should be within earshot of distant cannon, and perhaps of big bells tossed about by the waves.

It might be supposed that such an island does not exist on the face of the waters, and yet it does, and through the extreme courtesy and generosity of Trinity House I found it.

It was a proud moment with me when, early in November, 1898, I received instructions from Tower Hill to repair to Trinity Wharf by the evening of the 14th, and to be in readiness to go on board the Trinity yacht *Vestal*, under Captain Eastham, who would at the time of the monthly relief proceed to visit all light stations between Gravesend and the open sea. I was to provide myself with all necessaries, food and bedding, which should be sufficient in quantity for a possibly protracted sojourn on the isolated station to which I should be conveyed. To the outside public these instructions were not altogether precise, and some vague tidings having reached the Press of my movements, a paragraph appeared in one of the papers to the effect that I was about to be "marooned" for an indefinite period on a desert shore.

The date arranged was, it will be noted, the time of fogs, a time when experiments in sound observations prove of special value and importance. But the early part of November went by without the semblance of a fog, and I began to fear that I should experience nothing but the monotony of fair weather. So brilliant was the afternoon of the 14th, that in spite of the time of year a perfectly successful snap-shot was taken of the start from home with my strange looking belongings. There was the same fair weather in London at 6 p.m.; even at Fenchurch Street the air was perfectly clear, and the distant lights shining brightly down the line. I mention these facts to give point to the remarkable condition of atmosphere very shortly encountered.

Only a few miles out of Fenchurch Street and midway between two stations, the train, though running slowly, suddenly entered fog, not fog in the ordinary way, but a bank, or rather an abrupt wall of fog, blinding, dark and choking. I was unable to determine whether we were at the time very close to the river, but we never again got away from this fog, crawling thenceforward slowly and with frequent stoppages down to our destination, Blackwall, where it was densest of all.

Blackwall was—and is still—absolutely unknown to me, and when on alighting I enquired my way to Trinity Wharf I was told I could not possibly find it on such a night. If I felt my way a few yards along the wall outside the station enclosure, I should, through a side entrance, possibly find the constable of the dock, who would tell me if I could proceed.

My destination was quite close, but it was very doubtful if I could be conducted along the narrow foot way.

If this point seriously admitted of question the constable quickly answered it. No soul, he assured me, could or would be permitted to make the attempt. And then I learned, what was easy enough to credit, that no denser fog had ever been known at Blackwall, that it had endured for twenty-four hours, that not a soul was abroad in the streets, and that the entire staff of railway servants had for many hours been on emergency duties along the line. I was offered a "shake down" in the station as the only accommodation that I could obtain till the fog lifted. As an unanswerable argument to this suggestion, however, I produced my official letter, bidding me report myself that night to the Superintendent of the Wharf, and to the Superintendent I must go. When faced with necessity no one, I suppose, can be more resourceful than a railway official; certainly the Station Master showed himself an invaluable and true friend, and when the next train came in—not really the next, but one that should have been the last train but two—he took me himself up the line to Poplar, and there instructed a porter to take charge of me, and by aid of a railway lamp to feel his way round by the streets to the wharf gates.

In this way, after a mile of slow and cautious walking, or rather groping, I was conducted to the wharf, where I found the kindly Superintendent, Captain

Browne, who was abroad in the thick night, and awaiting me with some anxiety. He was far more anxious, however, about another matter. At 3.30 that afternoon one of his seamen, ferrying from the shore to the *Vestal*, distant only a quarter of a mile, got lost in the fog, and had not since been heard of. Captain Browne had much to impart to me relating to my own work from his own experiences during a busy and eventful life and forty years spent in the service of Trinity House. He was quite prepared to endorse what had been stated with regard to "Zones of Silence." He recalled an occasion when proceeding to Scilly from the Seven Stone Lightship he lost the sound of her siren at four and a half miles' distance. On reaching the mainland, however, he learned, from a friend who was out rabbit shooting twelve miles distant in the same direction, that the siren had been distinctly heard all the afternoon in spite of high ground intervening.

We had been talking within doors for the space perhaps of twenty minutes, at the end of which time the Captain went abroad again to seek reassuring tidings.

And these were already at hand. In those same twenty minutes Nature had wrought a miracle in her own fashion. As though by magic the fog had been banished utterly, and from all sides; not a trace of it survived, and up and down the river distant lights were shining brightly.

Had it been possible to climb aloft in a balloon that afternoon, and look down over a few miles of that reach of Thames, probably it would have been found that the murky cloud that had lain over the land had not only been confined within sharply defined limits, but had, after all, been extremely shallow. I was soon to have personal experience of what has often been established, that from a ship's masthead or the roof of a tall building it is often possible to look clear over a fog of the worst pea-soup type. It is said, indeed, that a small dog on the pavement, from his own point of view, can also see clear underneath such a fog, a fact which sailors now make use of by placing a look-out man on the "dolphin-striker" as well as on the "fore-top."

I cannot believe that that exceedingly evil fog which had lain so long over Blackwall and Poplar could simply, in a few minutes, have vanished into thin air like the Cheshire cat that left only the grin behind. The grin of a "London particular" could hardly be left behind without revealing itself. No, that statute number of hundredweights of soot motes to the square acre must each have gone aloft, and so away on little balloons of their own.

With no more delay I was now rowed off to the *Vestal*, and before I retired that night to the luxurious saloon usually reserved for the Elder Brethren of Trinity House, I had the satisfaction of having an interview with the lost seaman. His story was simple, but sensational enough as well as instructive. He had through the afternoon already made many journeys over the mere 400 yards that separated the wharf from the yacht, but at last he found himself wrong, not only missing the ship, but failing even to hail her. Realising the gravity of his position, he continued to row hard and call loudly. Soon, however, he was overmastered by the current, and so drifted helplessly for two long hours, being fortunate enough to avoid fouling anything in spite of the crowded river, and when brought up at last he found himself at Woolwich Pier.

Getting under way the next morning, we continued to make steady progress through a busy day, and being invited on to the bridge, I was favoured with much valuable information as well as with many a yarn of past service from the genial Captain. Among other matters, he was able to tell me much of the olden days when Professor Tyndall had occupied my own quarters on board, and had carried out many of his classical experiments in the interests of the world at large and Trinity House in particular.

Commenting on the phenomenal weather of the day before, he confidently asserted that wind would be a consequence of such a rapid clearing up of fog. Mist, however, had again prevailed with early hours, clearing off again at 11 a.m. with a rising glass, and when we dropped anchor at night-fall it was clear for a mile at least in all directions. Away on our starboard beam gleamed some evil-looking green eyes, which presently winked and closed. Shortly after they blazed out again greener than before. This, Captain Eastham told me, was the Mouse Lightship, and added that I had better have my kit ready on the morrow an hour before dawn.

The next morning I woke to consciousness with the sound of a deep bell at no great distance tolling slowly and solemnly across the water. At daybreak we were cautiously making way again through fog that was much thicker than on the previous day, and presently I was pointed out an unintelligible object right ahead, dimly looming and again disappearing in mist. For all that one could see it might have been some grim castle hung from the sky, for it had no visible connection with earth or sea. Anyway, it was my destination, and when within 400 yards' distance we dropped anchor it stood declared the Maplin Lighthouse. In sooth, it was as I had desired, an island well out at sea, but on whose shores the waves could never beat.

The Maplin stands high out of the water, supported on a strong but slender iron framework, which is firmly bedded in the shoals below. Thus, whether calm or rough, with ebb or flow, there is practically no lap of waves upon the beach. The Essex shore is six miles distant at its nearest point. To the S.S.W. and S.W. are Shoeburyness and Sheerness, whence the boom of heavy guns is constantly to be heard across thirteen and seventeen miles of salt water respectively.

It is hard by the great highway for all steamers between London and the North Sea. It is within occasional ear-shot also of a bell-buoy to the east. Last, but not least, four miles away, in opposite directions, are moored two lightships, one on the S.W., the Mouse, of which I have already spoken, the other the Swin Middle, to the N.E., and in their signals I should have excellent means of making valuable observations night and day, fair weather or foul.

With sailor-like expedition I was rowed off in a boat, and then with bag and baggage hauled up some perpendicular ladders, when I found myself at once within my coveted retreat—circumscribed, certainly, but well appointed, airy, and, of course, like all else belonging to the service, scrupulously orderly and clean. Above the main keeping-room and offices sprang up the huge lantern, outside which, and free to all the winds that blow, an open gallery was carried round thirty feet above low water, and affording an admirable outlook towards every part of the compass. So far, however, my retreat could hardly have been termed peaceful, for every half minute a ponderous stroke on the lighthouse bell above smote on the ear and sent a quiver through all the building. This had gone on from early dawn, and had, I was told, been the order of early mornings for some days past. The early mist would gather till mid-day, when it would draw off to the eastward along the Essex shore.

Armed with this information, and having had my first meal in my novel abode, I had my instruments conveyed up to the gallery, and commenced watch at 11 a.m. A gentle wind was blowing from the W.S.W., and the barometer still rising. It was now a drizzling rain, and as the fog continued it was quite certain that the fog-horns at both the lightships must be sounding continuously, yet that to windward, which came from the Mouse, was heard less distinctly, and twenty minutes later, the rain having ceased, became inaudible, while the horn of the Swin that opposed the wind grew louder. Two hours later the fog had rolled away down the estuary, and the distance growing clear, all sound signals, including the Maplin bell, ceased.

At 4.15, as the light failed, fog must have again enveloped the Mouse, for her horn now sounded loudly. Around the Swin, as also around ourselves, it was still clear and remained so until 2 a.m., when blackness settled down and our bell recommenced its warning.

At 3.15 a.m. I was again on watch on the gallery, with our big bell still complaining to the night, but the wind had veered and was now blowing a light breeze from the N.N.E. At this time the horns from both the lightships were audible, but that from the Mouse, though now coming against the wind, was the better heard. Four hours later the Swin alone was sounding, but most distinctly, conditions at the time remaining unaltered, with the exception that now it was low tide and the sea calm, while the fog, as usual, was rolling off to the east in heavy masses.

I have thus far only recorded briefly the sequence of one class of observations, and it happened that from this time, the character of weather changing and fog nearly disappearing, the indications given by stationary fog-horns came to an end. It had, however, been made clear that their sounds, as heard from the point of observation, were influenced in a far greater measure by the circumstances and qualities of intervening fog than by a gentle wind. Moreover, a horn which had been nearly quenched by interposing mist was observed to sound with far more than normal intensity as soon as the fog had rolled away behind, forming a background to gather and reflect the sound waves. Confirming and supplementing such observations there was much valuable information to be gathered from the experiences of the two lighthouse keepers who were sharers of my solitude. And it was not difficult to understand how authorities have differed so greatly in their statements with regard to the effect of fog on sound. Stevenson has declared, as the result of his own experiments, that sound is much lost in foggy weather, and is heard at a comparatively short distance. On the other hand, Tyndall asserts that "fog particles have no more influence upon the waves of sound than the suspended particles stirred up over the banks of Newfoundland have upon the waves of the Atlantic."

My own belief is that both authorities are equally right and equally wrong, from the fact that there are different conditions of fog. A uniform quiescent fog may offer no obstruction to sound whatever, while, on the other hand, rolling masses of fog of varying temperature and density may impede sound waves or even reflect them.

CHAPTER XV

A MODERN ROBINSON CRUSOE

Many most curious facts are forthcoming as to the difficulty of locating sounds. It is a very old trick to deceive anyone who closes his eyes as to which side of him two half-crowns are chinked together, and I must own to having been completely mystified in this way by an expert conjuror. But the experiment is hardly a fair one, for it is always performed indoors, where the sound is doubled back from walls and floor and ceiling. It is a different matter out of doors. A blindfold but attentive listener out of doors will scarcely fail to indicate exactly the direction in which a faint reed is blown, however artfully the experiment be arranged. Again, it has recently been stated by a master of a school for the blind that "a boy in still weather can strike down a single pin with a ball three times running at forty feet, a bell being rung over the pin."

We can set against this the fact that the grasshopper as also the corn-crake are accredited with powers of ventriloquism, remembering, however, that their calls are emitted in the midst of long grass or standing corn. Moreover, the bird at least is gifted with rapid powers of locomotion, and it may often happen that the mystifying sound may proceed not from one bird, but from several. It must also be conceded that certain sounds in their nature may be peculiarly perplexing. In an engine-room, where some small bearing needs lubrication, it will betray the fact by a thin shrill screech or whistle, but it is often impossible to locate the sound. The same may be noticed, too, in a minor degree when a bicycle squeaks, though the rider cannot tell where.

One phenomenon I was constantly on the watch for, viz., anything that might be interpreted into an aerial echo. Guns and hooters were constantly sounding around, and as the greater part of the entire twenty-four hours was given up to observation and no obstacle to sound was within a dozen miles, I had reason to hope that my wish would be gratified. Not a suspicion of such an echo, however, occurred till late in the afternoon of the second day, when, while standing on the gallery with one of the light-keepers, we noticed a Dutch vessel coming down the steamer track, and keeping as close in as the shoals would allow. When at close range the pilot waved his arm as if in greeting, and immediately after blew a double blast with his siren. There was no doubt that, my present purpose having been commented on in the papers, this unwonted salute was intended for myself, and it was a happy circumstance.

For immediately there followed a clear and prolonged echo, coming as if out of the empty air and curiously against the wind. So striking and convincing was this echo that I promptly entered a memorandum, and firmly and fondly did I believe in its aerial origin till the following spring, when, as will be told, I had reason to modify my views.

It will suffice here to recall the fact that when the sea was calm the sounding of the lightships' horns was much intensified, doubtless owing to the reflection of sound waves off the intervening water surface. The converse of this should hold good, so that when the sea becomes roughened the hearing would be impaired, and further, it would be conceivable that troubled water might, by scattering the sound waves in all directions, throw back some of them so as to cause an echo.

Nothing was more marked than the fluctuations in the hearing on days when circumstances of weather remained unsettled, and on such days a peculiar fitfulness of the atmosphere, which was the undoubted cause, could generally be clearly discerned if carefully looked for. The case is different from that on land, where, as has been seen, the air is often in turmoil from currents gendered of variously heated surfaces. The open sea surface, on the contrary, is perfectly uniform and continuous, yet it is only necessary to compare the official entries, made every third hour at adjacent light stations, to see how, over only a small area, different spots will be very differently affected by air motion. Our own eyes may detect the nature of this varying motion when the atmosphere is thick with rolling fog and drifting cloud, but even when these disappear from sight the air may be supposed to remain in the same disturbed condition.

A finial on the Swin Middle was a good test object for sight from the Maplin in clear weather. At 9 o'clock one morning when the sky was uniformly overcast, I turned a seaman's telescope on the above object, and examined it attentively for a length of time. The air, which had contained much moisture during the night, was drying off, and the wind, which was blowing from the east a gentle breeze, had in two hours dropped entirely. The object scrutinised was about twenty feet above the water, with a background of unchanging grey sky, but its visibility was most capricious. For a time it would fade, and reappear with perfect regularity through a cycle of phases, after this a period of total obscuration might occur, but if patient observation were sufficiently continued, a time would come when for a moment it would shine out again with tenfold distinctness. There was the closest analogy here with the hearing noticeable at the time from the same observatory. A steamer, plodding up the track and holding a steady course, would make itself heard in most fitful fashion, its sound at one time waxing and waning like the rise and fall of distant bells, presently swelling to a roar, and anon dying out altogether. It was the same with the boom of great guns coming more than a dozen miles across the water from the opposite horizon. Once, however, about an hour and a-half after sunset, when the air was growing dry and keen, and the wind rising somewhat in gusts, the throb of a distant steamer was caught and lost again immediately. This was distinctly noticed many times at varying intervals, and at last the direction was clearly located, and pointed to a steamer to windward far down the channel beating up against the ebb. It was fully twenty-five minutes, however, before the sound became continuous, or, in other words, the first fugitive sounds were caught at some five miles' greater distance than the normal sound.

Fitting in here is a story of this lighthouse dating only a few years back. About 9 o'clock one evening in mid-September, when a gusty wind was blowing off the land, the head keeper, who was off duty, heard through the open door of the sitting-room a distant cry of distress. He at once communicated the circumstance to the assistant keeper, who, being busily engaged inside the lantern, could not possibly have heard the cry. Both men continued to listen for a long time without hearing the sound repeated. They, however, noticed a signal-rocket thrown up near the shore, about five and a-half miles away. Five hours later in the night a shipwrecked crew in an open boat hailed the lighthouse, and coming on board soon proved that it was their cry of distress which had for a single moment been heard across the wide interval. They had in reality shouted repeatedly, but only for one fleeting moment had their cry reached the lighthouse.

So far there had been no chance of finding, and still less of defining, the limits of a zone of silence, and, to speak truth, I was growing sceptical. To begin with, there had been no sufficient evidence in all the reports to which I had had access that any zone existed. The conception of a zone seemed arbitrary and unjustified by any scientific evidence forthcoming, whereas it was already very conceivable how regions indefinite in outline or area might temporarily exist where such a sound as that of a siren might fail; for if layers of air at different densities could commingle in such a way as fitfully to blot out of sight a distant masthead, a like turmoil of atmosphere might equally quench a particular sound at a particular place. At the same time, the sound might be perfectly audible again further out, and even directly beyond the place where it was lost, as a moment's consideration will show. A siren or fog-horn, blown at the Coast Guard station at Marazion, might easily escape being heard by an observer in a boat lying sheltered immediately behind, that is on the south shore of St. Michael's Mount; but were he to row further out towards the south, still keeping the Mount between himself and the station, in all probability the note of the horn would now fall on his ear, by reason of the fact that the sound waves begin to bend round the intervening island and manifest themselves exactly as the Atlantic billows will bend round and manifest themselves everywhere save under the immediate lee of that opposing rock.

Without properly organised experiments, carried out scientifically and for a considerable period, it is not likely that anything conclusive will be arrived at with regard to the perplexing, but certainly most important phenomena of sound which we are now discussing. But there were many other phenomena which came under the observation of myself and companions during my Robinson Crusoe experiences.

The third night after my arrival, during a watch from 3 a.m. to 4.15 a.m., new conditions seemed asserting themselves. The wind that had been prophesied had not reached us, but there had been many indications of its approach, and now, though the air was for the time almost still, the stillness was of the nature that suggests a coming storm. The glass had somewhat fallen, and high up masses of cumulus cloud were scudding across the sky, from out of which the stars shone with great brilliance; and presently little gusts arose, always speaking softly as they passed. They were telling some message, but in an undertone. Round the gallery, and supporting its railing at intervals were upright 4-foot lengths of gas-tubing. These were designed as sockets from which to fire rockets, and the wind playing across their open mouths would often evoke an organ-like note; but to-night the puffs of wind woke a more melodious and plaintive piping, while through chinks and cordage there was heard the familiar "soughing" which one associates with coming wet. Then, too, my acoustic instruments began to say strange things.

With these instruments I had often listened for the murmurs which will reach one up from earth when sailing at heights where the unaided ear can catch no sound. Some of these ear-trumpets were made adjustable, so as more readily to catch faint sounds according to their nature and pitch. Listening attentively through these, I could detect what had not been noticeable on any occasion before, a rhythmic rise and fall in the murmur of the waves. Earlier in the night this murmur had become markedly softer and more subdued than on previous nights, as though it came from some distant organ of which the swell had been closed.

Somewhere in the S.E. the wind and wet were hurrying up, and the gentle but regular swell and lull in the night air which I have described was heralding their coming. Another new indication was also at this time noticeable. Before midnight the green lights of the Mouse had shone out across the four miles of salt water with an unwonted steadiness and brilliancy. They were still shining very brightly, but were manifestly somewhat paler, although the darkness of the night remained unaltered.

The sequence of changes seemed to indicate the progress of what is known among meteorologists as a wedge-shaped isobar, or area of high pressure that is travelling between two cyclones, there being on the one hand the rear of a retreating cyclone, and on the other the front of an advancing storm. In such circumstances it is well known that great visibility is often manifested.

Far seeing is commonly recognised among look-out men as a sign of coming change, and I was told on the Maplin that when the sheen of the North Foreland Lighthouse—standing more than twenty miles distant to the S.E. and facing eastward—could be seen in the sky then wind might be expected, generally from south and west, and probably accompanied by rain. I am convinced that many valuable prognostications may be found in the study of the visibility of lights, especially at night. Not only do far seeing and the reverse convey special messages, but even the colours of known lights may tell their own tale. I had seen a thick atmosphere heavily charged with matter in suspension settle down to landward, and in a short period of time the white light of the Swin turned to yellow, while the green light of the Mouse, emanating from an equally brilliant source faded and ultimately died out altogether. Again there had been conditions of weather when the green rays and the white would fairly vie with each other in brilliancy; and these different appearances seemed closely associated with weather changes.

The message which the soft sighing of the night breeze had been telling was realised by the dawn. The wind was then from the N.E., and by seven o'clock it was blowing stiffly and lashing the water into rapidly rising billows. And this condition of weather, which had been long foretold, proved long-lasting, and in fact terminated the experimental work which I had embarked upon. With a continuance of hard grey sky, a wind that blew steadily and stiffly, and an unchanging and noisy sea always uniformly clear to the farthest horizon, the entries in our note-book soon became mere repetitions. There was after all such a thing as monotony on even an ideal retreat like the Maplin Pile Lighthouse. I therefore placed myself in the hands of the light-keepers to effect my return to England if they saw opportunity.

Of these my companions I have said too little. One knows what to expect in picked men trained and promoted to a responsible post in such a service as that of Trinity House. They possess all the resourcefulness of the seaman, together with that quickness of apprehension which comes to men naturally intelligent, whom their vocation compels to be constantly observant and discriminating. Over and above this, however, my friends were extremely well informed, not to say well read, and in their habit of seeking and acquiring varied knowledge lay their surest safeguard against the *ennui* which would probably otherwise attend their enforced isolation of two months' duration at a time. Communication with the mainland there is practically little or none save by telephone. This, however, brings them into direct intercourse with one or more individuals on a land station, and in this way a somewhat peculiar state of things may come about. Two men at opposite ends of the telephone wire may have been in constant communication for years. They may incidentally have learned all about each other, becoming fast friends the while. They will be familiar not only with their mode of speech, but with the very tone of their voice, and yet may never have met or seen each other's face.

It was early one stormy morning that a steam barge, well-known to my companions, was sighted coming down the steamer track. This was duly signalled, and though the sea ran so high as to make it difficult to launch the lighthouse boat, yet by skill and hard rowing I was got alongside the little vessel and soon found myself on board, outward bound for Colchester.

CHAPTER XVI

FOG SIGNALS

During the winter which now followed I put myself in communication with a large number of Coastguard stations round the coast, seeking from individual watchmen independent replies to a number of printed and well-considered questions relating to sound and its vagaries. These replies, which would fill a large volume, are carefully and candidly given, and form a valuable record.

One significant fact elicited was that out of the very large number of those whose statements were thus obtained, not one could assert that he had ever heard what might be taken for aerial echoes. As to these the results gathered from my own experiences had also been almost entirely negative, and it occurred to me that I was now in a position to put these coy phenomena to a crucial test. The powerful detonating fog signals, with which I had become familiar, would be admirably adapted to my purpose. I had but to take them away into the sky and discharge them in all regions and in all weathers, and if the echoes from the void were anywhere in hiding I must surely discover them. A preliminary experiment, however, was here advisable. It would be well that the aerial cannonade should first be heard from below, and excellent place and opportunity for this lay to hand.

Three miles eastward from my own ground and on the same high land lies an extensive heath—a wild uncultivated tract, remaining probably very much as it was a thousand years ago. Here, on peaty soil, the heather and the bracken grow wild, struggling for territory against the more aggressive gorse, which, waxing stronger year by year, kills down all vegetation beneath it, while with long range artillery under the hot sun it flings its seeds into every rival camp. Thus the unequal fight goes on till such time as some mischievous urchin shall introduce a lighted match on an idle afternoon in dry weather, when half a square mile is at once in flames, which, sparing nothing, leave only blackened waste behind.

This desolation, however, is but the start of renewed life and vigour; for out of the ashes vegetation springs more luxuriant than ever, the bracken now for the time winning ground everywhere and showing that through all the period of oppression it was subdued indeed, but exterminated never. If a corner of my own kitchen garden be left uncultivated, in only a couple of years it is occupied by the bracken and the broom, ready at all times to assert their right to the ancient soil. An apparent inconsistency, however, exists at the spot to which I am about to refer. Here was an old-time race-course, now disused for a hundred years and more, and though the wild growth of the heath asserts itself up to the very edge it encroaches nowhere at all upon the close, rich grass. The true cause of this may be detected with but little scrutiny. Right and left among the furze may be seen a few scattered sheep, a dozen cottager's cows and the tinker's donkey. These enjoy free rights of common, and between them they keep the sward in as true and strict cultivation as though it were the sacred turf of the squire's lawn.

Here and there a clump of self-sown pines have combined to establish themselves. This is mainly on the bleak, high ridge, but where the ground slopes towards the valley forest trees and undergrowth find shelter, and combine lower down to form extensive woods. This will sufficiently describe the nature and surroundings of a spot on Bucklebury Common, where the experiments I have to relate took place.

The Messrs. Maskelyne were again my colleagues, and with their aid as careful and conscientious observers little preparation was needed. We were provided simply with the best form of instruments for receiving and locating sound, and with explosives that could be fired either on the ground or overhead from rockets.

It was a still, clear spring morning, the hour about 10 a.m. Having taken our station on the highest and most open part of the common, a heavily charged shot gun was first fired repeatedly at 100 yards' distance. This gave an unvarying result which was soon completely and satisfactorily interpreted. From all sides every clump of trees within 400 yards responded distinctly and in due order of distance, but beyond this there was no further reverberation of a definite character. Next, at the same point and about 3 feet above ground, four-ounce cotton-powder cartridges were fired, the report of which was returned from the same obstacles as before, and also from others further off to a distance of some 700 yards, within which range every clump of trees in sight, but none others, gave back a clear short echo.

This result being sufficiently verified, a cartridge of the same calibre was now fired from a rocket so arranged as to explode right overhead. It happened, however, that the rocket was really overweighted, and, pitching too soon, exploded at a height estimated at little over 100 feet. But it was high enough for a most startling result; for now not only were all echoes intensified, but new ones were evoked which were little anticipated. From the valley below and entirely hidden from view by the intervening shoulder of high ground, the more distant woods now echoed widely with a far "crash." Precisely the same result was repeated with each fresh trial, and an important fact seemed here to be learned, namely, that the sound waves in this case bent over the crest of the hill so as to strike the unseen woods, from which echoing back they would a second time bend over the crest and so strike the ear. It was absolutely certain then that a powerful explosion might create an echo from, so to speak, "round the corner." This might put a totally new interpretation on Professor Tyndall's experiences when standing under the South Foreland Cliff. In these experiences, which I have already given in his own words, he states that the "so-called aerial echo followed so hot upon the direct sound as to present hardly a sensible breach of continuity between the sound and the echo."

After all, however, seeing that the echo followed the initial sound so speedily, was he not simply listening to echoes from round the corner of the nearest cliffs?

One further result obtained on Bucklebury Common remains to be told. Immediately after the explosion of each rocket, a curious crepitation was heard all around, to the fancy in the air, and so, for the time at least, it must remain an open question whether these were real aerial echoes or whether they were not mere reflexions off the gorse bushes round. For I shall later give sufficient proof that a report which comes from earth may readily be mistaken as coming from the sky.

The next step, clearly, was to take the cotton-powder cartridges away into space, and fire them in the silent air, high and low, far and wide. And in this project I met with the readiest co-operation from the London Press. It was freely announced that on

Easter Monday I should ascend from the Crystal Palace with a battery of fog-signals and fire them electrically beneath the car. Further, observers of aerial sounds were invited to make notes of all they heard and duly report their observations. In the end what happened, although an entire failure, is well worth recording.

As announced, I attended at the Crystal Palace with formidable-looking paraphernalia and many rounds of fog-signal cartridges, one of which I proposed to fire by way of trial. I was, however, at once met by objections. There was a large crowd, and the neighbours disliked explosions in the grounds, and so forth. Therefore I simply got everything in order before the start, and as soon as we were a few hundred feet aloft I suspended a cartridge beneath the car and applied the voltaic current. The result was *nil*—constantly *nil.* In vain I readjusted the cartridge, brightened the contacts, and worked the electrical machine madly. Simply nothing happened, and then, too late, there dawned upon me the suspicion, subsequently confirmed, that my cartridges were furnished with low tension instead of the more usual high tension detonators.

And so none of my bombs were fired after all; and yet what matter? In due course of post came a flood of letters from enthusiastic correspondents who had heard them distinctly all over the country and could give accurate information about them.

Now in this I believe there was perfect candour and no sort of mystery. It was Easter Monday, and in a great many places, as I myself can testify, there was rifle practice going on. And so it came about that when a distant rifle was fired at a target the minds of many decided that the sound came out of the sky.

That this is a familiar trick of the mind I can give further proof. It has been recorded again and again in text-books that the sound of a bursting meteor has been heard on earth, and that this is a most remarkable fact, seeing that meteors are thought often to burst at a height of some sixty miles, where the air must be too rare to be supposed capable of conveying sound at all.

Now let us consider what this statement implies. The sound may be taken as travelling approximately at the rate of a mile in five seconds, from which it would follow that sixty miles could not be travelled in less than five minutes. Is it likely that the observer of a meteor has listened patiently for five minutes and then recorded a report which really might have come from anywhere? Is it not far more probable that in the cases recorded some earth-born report, closely following the meteor, has tricked the fancy into imagining that it came from the skies? Regarded in this light, an apparently aerial echo would surely demand most conclusive proof, and I set about preparing a yet more decisive test. Meanwhile it is just worth recording, by the way, that the termination of the balloon ascent just referred to took place close to Dover, and we thought ourselves lucky in happening to catch an express (!) train returning to London. Certainly it was Bank Holiday, but even then it may seem noteworthy that the journey by S.E.R. was almost exactly three times as long in duration as that by balloon!

CHAPTER XVII

HOW I BOMBARDED LONDON

Rough weather followed this ascent, necessitating a period of inaction, which I employed in announcing my intention of repeating the experiment that had failed. But I had now grown ambitious and possibly overbold. I was determined so to arrange matters that my balloon should travel right across London itself, and over the very housetops I would commence a bombardment which should at least secure the attention of many thousand observers capable of giving a good account of the effect noticeable below.

Whether any out of those thousands would object to being thus cannonaded, that I must leave simply to the fates to decide. But the task was no easy one; indeed, the difficulty of piloting a balloon directly over London may be readily conceived. Happily, however, Messrs. Spencer, by establishing four or five different ascending stations round the suburbs have rendered the feat at least a feasible one so long as the fortunes of war are not altogether adverse.

On the first day advertised we were entirely foiled by storms, but a few days later it seemed possible to achieve our object by ascending from Barnes, and arrangements were already in progress during the morning, when the wind suddenly shifted its direction, veering several points towards the north, and an immediate countermove on our part became necessary, whereupon the balloon was packed up and hurried off seven miles by road to Hendon. It was, however, by that time two o'clock, and it was two hours later before preparations were again completed, by which time the sun was already low in the sky. But another postponement was not to be endured, and so by six o'clock, all difficulties being finally surmounted, the balloon was full and tugging at her moorings. Not, however, so lustily as an aeronaut loves to see.

Probably owing to a heavy quality of gas there was a deficiency in lifting power, and this was the more unlucky as there were to be four in the car that evening. For I was fortunate in having secured as a colleague Mr. Thomas Simpson, an old friend with whom I had sailed on an eclipse cruise to Lapland, and whose skill and accuracy of observation I could ill dispense with. Moreover, my son was acting as artilleryman and must not be left behind. Thus it came about that we had to abandon our anchor as well as half our trail rope, and with only a few pounds of ballast we lazily floated up in the heavy evening air. Our course lay over Willesden, at a rate that was exceedingly slow, and this was so far well, as we should the longer linger over outlying London, and it being an hour when many hands abandon work, the streets would be full of likely and unoccupied observers.

We had not ascended more than 1,500 feet when, the ground below being still fairly open, we fired our first shot. It was probably the first powerful report that had been fired from a balloon since the days of the older aeronauts, who sometimes fired small cannon and maroons at moderate heights for the entertainment of a gala crowd below. As far as I can learn, it was certainly the first time that modern high explosives had ever been experimented with in this way. To all of us in the car the result was unlooked-for and astounding. We knew well the effect of our cotton-powder cartridge on the ground, we knew of its power to carry across many miles of sea as a fog-signal. We remembered one being fired in private grounds a year before, when 100 yards off in a marquee a large party were being served with tea, and when the report was immediately followed by a crash within the tent, caused by everyone dropping his teacup. We knew all this, and so nerved ourselves for a stunning shock so soon as the cartridge hanging only 120 feet below us was exploded from the car amid the silence that prevailed around. Our astonishment, then, may be conceived when on revolving the handle of the dynamo a mere modest report followed, not greatly louder than that of a pistol.

Of course we learned to be wise after the fact, and knew that we ought to have been prepared for this; of course we ought to have remembered how, in all our experiments, background was found to have everything to do with the amplification and redoubling of sound, but none of us thought of all this at the time, and so we each involuntarily remarked on the futility of our signal. But once again we were mistaken, for our exclamations were scarcely uttered when they were rebuked with startling sternness. With a mighty burst the earth spoke back, returning the sound waves with a peal of thunder. True thunder it was of the loudest description, and flung back from objects far afield, causing long and loud reverberation.

This was our first lesson, and a valuable one. Our object was to compare our results in the car with those which should subsequently be communicated to us by observers below, and principally to listen with all our ears for any aerial echoes. We prepared therefore for a second shot, resolving to keep absolute silence between the explosion and its earth echo so as to catch any faintest murmur that the mere air might send us. But ere all was in readiness we had risen to 3,000 feet, or twice our former height. We were, in fact, half a mile above the actual ground beneath us, and it seemed almost unreasonable to expect that echo could answer with any intensity over so great an interval.

Again our pistol-like report rang out — possibly feebler than before in the now slightly rarer air; again absolute silence ensued, though we all held our breath, stop watches and aneroids in hands. We waited five seconds, and five seconds is a long time to those who watch and wait. Moreover, five seconds is approximately the interval which sound should occupy in travelling a mile, or, in other words, in making the double excursion from the bursting cartridge to the earth, and from the earth back again to the balloon. Were we beyond earshot? As to this there was to be no mistake, though there was apparently some mistake in time. For a full second too late the thunder rolled out almost as loud as before and far longer in continuance. During forty seconds at least the reverberation lingered on distinctly, and the facts now given were accurately entered in our note-books.

We were over some large gas-works, probably the same which had supplied the gas we carried, when we were in readiness for our third round. But the question was gravely debated whether it were wholly safe to employ such tremendous artillery in proximity to gas-works inasmuch as we were approaching the earth again, and to us the effect of our detonators was simply stupendous. There seemed little doubt but that we should hear plenty about our experimental cannonade when we got down, even if we did not get seriously reprimanded. For the present, however, we were fairly out of reach, and the feeling was that we might as well conclude our trials while we had the chance.

Of course, in the end we did blaze away over the gas-works, and of course no harm came of it, but the result of this shot was the most startling of our acoustical experiences that evening, owing, as I suppose, to the houses being now somewhat nearer as well as far more numerous. But there was the further fact noticed, which indeed applied to our whole series of trials, that on every occasion the echo was behind its time.

Necessity now compelled us to part with nearly all our slender stock of ballast with the result that we once again reached some 3,000 feet, by which time we were over the huge burial ground of Kensal Green. It must surely have been very large for we were an extraordinarily long time passing it. Then Westbourne Park and Wormwood Scrubbs glided sluggishly beneath us, while crowded Kensington lay beyond, and here we continued a brisk salute, with results substantially similar to those already recounted.

But soon our attention was turned to other matters. We had reached Earl's Court and were hovering directly over the wheel—a tiny toy wheel it seemed; it would be an admirable spot we thought for a fresh salute if we could fire one in time, so we hurried the needful preparation, hauling in the cartridge, attaching a new one and lowering it to a safe distance. But there was no need for hurry. Our balloon to all appearance was waiting for us, and when all was ready we were still hovering almost directly over the big wheel.

Then the unwelcome fact dawned upon us that we were becalmed. We had for some time been travelling very slowly, and now further progress was almost entirely arrested—a serious predicament without a remedy. The wind, which had been light throughout the afternoon, had practically dropped at sundown, and in these circumstances there was but a remote chance of its freshening again for some time. It might well be that there was more wind overhead, but we had no spare ballast with which to effect a rise; worse still, we now found that we hardly had sand enough to save an immediate descent on the house-tops. The district lying between Old Brompton and Fulham Roads stretched just before us, and it looked as if we must abide the consequences of coming down in the middle of that crowded quarter. We were actually trying to determine the spot which we should probably invade, when suddenly to our horror a street below us was lit up with a string of gas-lamps, and then another and another. It was the hour after sunset, and quickly all the ground below us was closely occupied with an army of naked flames ready to receive and annihilate us.

The danger from these street lamps was indeed a real one, for as a balloon reaches the ground its gas is copiously escaping into space, and this by mingling with the air becomes a highly inflammable and explosive mixture, and it is from this cause that balloons when brought to earth have not infrequently caught fire simply from some bystander lighting his pipe at a little distance. Moreover, a balloon on alighting generally sweeps for some distance along the ground, and this, in a London thoroughfare, would almost infallibly mean collision somewhere with a lamp-post.

At the moment of which I am speaking we were fairly poised in space, neither ascending or descending, but as the chill of night was coming on there was every probability of our shortly settling down, and it happened, too, that we were without means of governing our balloon in any way, owing to a mischance, which so far I have omitted to mention.

The packing up of the balloon at Barnes had of necessity been hurried, and the inflation at Hendon yet more hurried, so that the adjustment of the tackle, which is always apt to get itself into some entanglement, was somewhat hastily carried out. The valve at the top was certainly carefully seen to, and the valve rope, coiled up, was duly placed inside. Later also what appeared to be the end of this rope was seen protruding below from the neck of the balloon as it filled and unfolded itself. Finally, however, when the moment for the start arrived, Mr. Spencer, on taking hold of the rope's end just mentioned, found it to be only a short loose length, while the true valve rope remained coiled up hopelessly out of reach. Thus it will be seen that in our critical position over London streets we had lost all control over our balloon, which, it seemed, must therefore be left simply to its fate.

In this emergency Mr. Spencer's eye fell on the dynamo, with which we fired our cannonade. Now this dynamo was a costly instrument; it was, moreover, borrowed property, and therefore had every claim to be carefully treated. It was, however, heavy, weighing perhaps as much as an ordinary bag of ballast, and in this therefore might lie our salvation. I remember pleading hard for this instrument, which I had faithfully promised should be restored without injury. But the necessity which faced us overruled all other argument, and so a label was written out and attached to the dynamo requesting that it might be forwarded to the Egyptian Hall. The trail rope was also hauled in, with which the heavy instrument might be lowered to the ground as soon as opportunity occurred. This occupied a little time, and in that little time a change had been taking place which we scarcely hoped for.

There is nothing more fickle than the wind, and though it would have been a moral certainty under ordinary circumstances to predict a continuance of calm, yet the circumstances of the present case were not quite ordinary from the fact that we were approaching, however slowly, a river bed. I shall later have to tell how, on two occasions, the course of a river flowing below has completely dominated a balloon floating high above it. We were destined to notice something of the same kind now.

Our motion, as I have told, had almost ceased, yet we did just creep on, and the fact of our not sinking must have been due to some upward current, for a current of some sort began manifesting itself. Clearly, following the course of the river itself, an upper stream of air was moving, and as we crept on towards the Thames we encountered it, and finally were wafted clear of the river, and dropped in open ground at Willesden.

It may be supposed that I waited with some anxiety for the remarks or censure which the public would have to give, and I had not long to wait. Letters poured in to myself as well as to the offices of the daily press from a multitude of observers all over the metropolis and from far away in the suburbs. Most frankly and gratefully I must own that London took the whole affair extremely good naturedly. Not a word of complaint reached me, although, as it seems, the windows shook at every explosion. Some thought that the field artillery were having a big practice on Wormwood Scrubs, others that some alarming accidents were happening in the next street, others that a heavy thunderstorm was coming up, and so on. But among the whole number of observers there were not above two or three who noticed any reverberations, and in no case were these described as at all prolonged. To me this at first seemed almost incredible, and I never fully reconciled the fact to myself until the following autumn, when I attended some of the firework displays at the Crystal Palace, including that of Messrs. Brock's benefit night. It was then I noticed what any visitor may observe for himself, that the larger maroon shells, which burst at high elevation, are attended with only one or two short echoes, and this in spite of their very powerful report. They awake no echoes approaching those that our rockets, exploding at a low altitude, aroused on the open common as described in a former chapter.

One noteworthy fact established was, that our exploding cartridges were heard at distances that must be regarded as very considerable, when the absence of background is taken into account—farther, in fact, than a clap of thunder is generally heard, though not so far apparently as when the same cartridges are fired close to the earth's surface.

Perhaps the most remarkable result of all gathered from our voyage was that which we ourselves obtained, namely, that the echo was always behind its time. It was a result almost impossible to believe. One matter, however, admitted of no doubt whatever. There had been no trace of an aerial echo in all our trials that night, for each explosion had been followed by absolute silence, until the waves of sound had reached down to earth itself and come back again. Clearly the right thing would be to repeat our experiments again under different conditions.

And the opportunity for this soon came.

CHAPTER XVIII

A NARROW ESCAPE

Whit Monday, 1899, was a dismal day for holiday-makers, and apparently by no means desirable for ballooning. The morning broke dull and damp, and gave no promise of better things. The wind was from the east, and at 9 a.m. from our high ground in Berkshire the outlook was altogether forbidding. In London by mid-day matters were worse, and on reaching the Crystal Palace the paths were found sodden by the damp air, and a fine drizzle was already commencing. Happily it was to be an early afternoon ascent, 3 p.m.; but by that hour the dense crowd of onlookers were all under umbrellas, and some photographs taken from the balloon ground show the near North Tower so shrouded in mist as to be but dimly discernible.

That same North Tower at the hour of departure gave us some little uneasiness, from the fact that the wind was rising in gusts and remained just in that particular quarter, which rendered it very possible that if any error in management were committed we might foul the tower, and with some violence. This made us study the actual direction of the wind very carefully. It also led Mr. Percival Spencer to take due precautions to avoid mishap, and by exercise of his unerring judgment the balloon was launched with a proper degree of lifting power and safely cleared all obstruction.

Owing to this manœuvre we ascended somewhat rapidly, and soon lost sight of the earth. Not, however, till our course was clearly and accurately defined. We sailed close over the North Tower, thence over the Palace itself, and onwards into the west. The shouts of the crowd died away, and for a while we remained lost in the dense wetting cloud which lay low and heavy over all the British Isles. This cloud was no less than 1,500 feet in depth and so dense that while passing through it I was scarcely able to see my companions in the car.

Soon, however, and suddenly the darkness grew less, and then with a quick transition like that of dissolving views we found ourselves in another world. We might, indeed, have been in another planet, or far removed in space, for the world to us was not. No sight or sound of any kind for a while could recall our proximity to earth. Below us lay a sea of mist tossed into lightest billows white as driven snow, and stretching into illimitable distance. Above us was the sun, till this moment invisible, and now such a sun as is never seen on English soil at all—

intensely brilliant and hot, almost overpoweringly hot. It was only the third week in May, yet the great orb shone more fiercely than in August, and out of a heaven of deepest blue. To witness such a sun and sky one must climb for half a day up some favoured slope in Switzerland. We, however, had reached the same bright, pure, invigorating region in less than twenty minutes, and it was almost impossible to realise that only a mile or so below us there was the dark, cheerless earth, the pitiless rain, and the bedraggled holiday crowd. Great was the temptation to indulge at leisure in the simple enjoyment of a glorious afternoon stolen from a summer not yet at hand. But there was work to be done, and the circumstances of the day made the work of special value.

We were equipped and ready to repeat the echo experiments described in the last chapter, and the day seemed one which gave excellent promise of noteworthy results. Dense clouds have almost universally been credited with a power of returning echoes, and we were certainly provided in our exploding fog-signals with a source of sound which would discover any lurking echo within earshot.

The writer of a technical article on acoustics in the *Referee*, speaking from his own sea-faring experience, says: "I recall an experience in California of a fog which was characterised by an exceptionally lively echo. It was capable of returning seventeen rapidly-uttered syllables most articulately, but when there was no fog there was no echo. Living in the district for several months, I had many opportunities of testing this phenomenon. I have often regretted that we did not think of stationing a man beyond the echo with a view of learning whether he heard us when we shouted. I have a strong suspicion, from the strength of the echo, that the area beyond it was an area of silence."

Arguing from this experience, we had good reason to expect that sky echoes would be met with during the present afternoon. We therefore paid the closest attention to our experiments. First, when about 3,000 feet above the cloud layer, we lowered a cartridge, and, stopwatch in hand, listened carefully for the result. It exactly repeated our former experience. Absolute silence ensued until full time had elapsed for the earth to reply, when the same peal of thunder rose up which we were already accustomed to. And this thunder was in no way diminished by the intervening depth of dense cloud which the waves of sound would have to traverse. Then we travelled on, changing our locality and also our height, continuing at intervals to fire cartridges, and as we did so to listen with bated breath and accurately note the interval before any echo reached us.

The result was always the same, and proved, first that throughout this afternoon there was never even the suspicion of an echo from the cloud or sky; and secondly, that the dense cloud layer below not only did not deaden the sound returning from earth, but if anything seemed to aid it.

But another phenomenon obtruded itself constantly and necessitated our recording it as a strange fact, namely, that there was always a *lag* in the echo, or in other words, that the interval which elapsed between the report and its echo always made us appear to be at a greater altitude than our instruments showed us to be. So unaccountable was this that we took the utmost pains to test whether our observations were correct. We changed our instruments and watches for others, and checked one another's readings, but the result always came out the same. The only uncertainty that could remain was as to the trustworthiness of aneroid barometers to record height accurately under the circumstances of a balloon ascent.

Now it happens that this matter has been carefully investigated by qualified experimentalists, who have shown that in ascending the index hand of an aneroid moves backwards in accordance with the altitude reached, but that if the ascent be arrested the index for a while still continues to retrograde, so that it finally gives a somewhat false reading. Then let us examine what this involves. A balloon rises steadily, say, to 3,000 feet, and there stops. Then the aneroid will duly record the rise up to this height, but when the halt occurs the index hand will still continue to run back till say another 100 feet is falsely recorded.

Thus the balloon is at 3,000 feet, while the aneroid records 3,100 feet, representing the height as greater than it really is. But it will be remembered that our recorded height was never high enough to justify the intervals of the echo. Thus, under the circumstances usually attending a balloon voyage, the lag in the echo, to which we have referred, is made the more apparent. It may be a question whether the fact—surely one of much interest—may not be attributable to the varying density of the atmosphere through which the sound has had to travel.

It should be mentioned that the letters which reached me from various quarters afterwards went to show that our reports were heard quite as far as they had been on the former occasion in a clear sky, affording one more proof that the dense cloud canopy in no way quenched the intensity of sound.

I would dwell on the fact that in all our aerial cannonade the echoes were not short and single, but continuous and prolonged, as though the ground below—often mere flat open country—threw back the sound waves from a long distance. If this were so, then the phenomenon noticed from the Maplin, and already recorded, which I took to be an aerial echo, might well have been only reflexions of sound from the waves of the open sea around.

After we had continued our experiments for some two hours with the same unvarying result that I have described, it occurred to us that it might be well to descend. The character of the afternoon had, as far as we could judge, in no way altered, all conditions appearing to be the same as when we were below. We had, however, never once caught the smallest glimpse of earth, and having had no means of testing our rate of progress, there could be no certainty as to our whereabouts. Yet we were confident that we should not be far out of our reckoning. Our course on rising had been clearly shown to be due west, and as our altitude had never been more than 5,000 feet we did not anticipate that our rate had been excessive. On a reasonable calculation we judged that now, at the expiration of two hours, we must be somewhere back in Berkshire, and this being a satisfactory calculation, Mr. Spencer opened the valve, causing us at once to descend into the mist below.

It was a long dark dive, for the cloud was as deep and dense as ever, and some time before the lower limit was reached our ears were filled with a strange splashing sound which was hard to account for. Mr. Spencer and myself had now for a long time accustomed ourselves to listen to and interpret the various earth sounds that reached us. We had learned to tell from sound alone when we were over trees tossing in the wind or within earshot of the race of a mill-stream or a water-fall. But the noise which now grew loud, and seemed to come from every quarter, was beyond our guessing, and quite unintelligible in our supposed locality.

Finally, however, we decided that it must be the splashing of rain drops on heavy foliage below us. Doubtless it was still raining hard on the earth, and we must be over some extensive Berkshire woods.

But on a sudden we emerged from below the clouds, and there was the sea and shipping close below us—so close that a cargo boat, conveyed by two tugs, which lay immediately in our wake actually had our trail rope entangled in her rigging. Now our trail rope was 300 feet long, our descent was gradual, and the lower margin of the cloud was sharply defined. It would be curious then to know what the crew of the cargo vessel thought of the sudden apparition from the heaven of a rope unconnected with any visible object, but sweeping their deck and coiling up among their spars as they passed. Their unfeigned astonishment was immense when a wicker basket loomed out of the mist, and two human heads, betraying astonishment equal to their own, inquired where they were.

In truth there was good reason for the inquiry, for we quickly discovered that we were, as at the start, going steadily on into the west. Had our progress aloft then been so rapid that in a couple of hours we had traversed the whole breadth of England and Wales, and were now out over the Irish sea?

Our interrogations were not intelligibly answered, and I must digress here to explain that they seldom are so, simply because your questions are generally replied to by a dozen voices at once. Moreover, you are apt to put your question wrongly. Your inquiry is always as to your whereabouts, and until you learn better you shout to the countrymen, "Where are we?" to which interrogation the reply is always the same, "Why, up in a balloon!"

The cloud continuing to limit our horizon it was some little time before we discovered that there was a shore at some distance on either side of us, indicating that we were in a river estuary, and by the amount of shipping passing up and down it appeared probable that we must be in the mouth of the Thames. And yet this seemed altogether a sheer impossibility, for it would mean that on this, a day of quiet rain and not of storms, there must exist above the cloud layer a strong current of wind blowing precisely in the opposite direction to that below.

For a considerable time our course lay exactly in mid-stream, and it was not until the well-known fort and dock of Tilbury stood out of the fog right ahead that we were fully assured of our locality. Then it was made clear to us that all the time while we were basking in the summer sunshine above the cloud canopy in apparent calm, we were really being taken back and hurried out to sea so fast that in another half-hour we should probably have been unable to win our way home. Ballast was already running short, and it looked very much as if we must eventually settle down in the river and trust to some friendly boat to save the balloon. Instead of this it was a chance puff of wind that came to the rescue, and we found ourselves edging towards Gravesend.

I was busied at this time in taking a number of snap-shot photographs, many of which proved eminently successful, and have been on view in some principal London exhibitions. One, however, I have considered it proper to withhold. I believe that a wise regulation prohibits anyone, at any rate if he be an English subject, from photographing a British fort. On developing my pictures, however, I discovered that one of them gave a most perfect presentment in plan of Gravesend Fort. It still remains, but quite safely, in my possession.

Presently we reached the river's bank, and eventually found ourselves over a town of some size. Then, too, we found that the end of our trail rope, which had been dragging with half its length in the water, began to cause some little excitement, for it was of substantial thickness and heavy with wet. It had a way of slanting across a street gracefully and, indeed, very harmlessly, but foot passengers stood astonished and vehicles pulled up short. Then it would climb the side of a house, tap gently on the slates, and then descend, again gracefully, into a back garden.

It may be supposed we watched its course closely and with interest, and presently there came a crash. "Mr. Spencer," I said, "I am afraid that's a chimney pot!" "No," he replied, "I think it's a window."

Let me at once assure my readers that the small damage which really occurred was shortly traced and duly compensated. Let me also explain, what may not be apparent, why we did not gather in the trail rope out of the way. The explanation is that this would have only caused far greater confusion. It will readily be seen that the very effect of drawing up the dragging rope would have drawn the balloon down nearer to earth, while every yard of rope lifted off the ground would have meant so much more weight taken up in the air. Thus the result of hauling in the offending rope would have been to bring the car itself down on the house tops.

The trouble did not really continue long for we chanced to find half a bag of sand left at the bottom of the car, and the discharge of this lifted us away some miles into the country.

When at length we reached earth in a field where there were many labourers we were questioned as to whence we had come, and our reply, "From the Crystal Palace," was simply greeted with shouts of derision. They knew all the country, and no assertion of ours would convince them that a balloon coming up from the east, as they had seen ours coming, had started from the Crystal Palace.

CHAPTER XIX

WIRELESS TELEGRAPHY IN THE CLOUDS

So far we had tried different heights, different hours, and different conditions with our aerial cannonade, and were still without a single instance of having an echo returned from empty space or dense cloud. Very many more experiments should undoubtedly be made, but pending opportunity for these I was fortunate now in meeting with the chance of studying freely and at leisure perhaps the most famous historical echoes in England—those of Woodstock Park.

By very generous permission of the Duke of Marlborough I was allowed, in his absence from home, to choose any day that seemed suitable and then to make any experiments that I desired without the fear of disturbing anybody. Woodstock Park is but 27 miles from my own abode, but those miles lie mainly across the open Berkshire Downs, where the roadways are hilly and little used, save by those who yearly go to attend the buying and selling of sheep at Ilsley Fair. The more legitimate way would be to go by train to

Oxford and thence on to Woodstock Station. This route, however, is circuitous, and the trains ill-matched, so that it was impossible to make the journey on any chosen day with leisure enough to carry out trials, which for their due pursuit might require the expenditure of much time, as well as the right wind and weather.

There had, however, recently come into the neighbourhood a motor car, the first of its kind in our part of the country, and there had been much talk and speculation about it, and many hard things said. But the owner being an old and intimate friend much interested in my own pursuits, it came about that we entered into an agreement to start together on the first favourable morning early and make a day of it.

It was, as intimated, a wild, rough way, and the motor car being still an unproved conveyance, there was something exhilarating in the off chance of meeting with a breakdown somewhere on the chalk slopes of the old Roman "Ridgeway," and seven miles from anywhere.

A start in the grey of a fresh, dull morning may then be pictured; our baggage, gun and gunpowder, fog signals and rockets in goodly number, to say nothing of horns and sundry noisy instruments, tuneful and otherwise. Surely, since the days of Fair Rosamond, Woodstock Park had never been profaned by the use of such diabolical apparatus.

Of the actual journey from home perhaps little need be said. Police are but little in evidence on the unfrequented tracks across the Berkshire wilds, and it was well to know what the new mode of conveyance was capable of accomplishing. We argued thus and agreed that there was no need to state in writing what our more special rates of progress were that day. Certain minor mishaps occurred. Our hats blew off in an unwonted way for a day that as yet was far from windy. My gun too would not remain on the back seat, and cartridges littered down in small cataracts and strewed themselves along the roadway.

These were lesser events, but at Oxford we were confronted by a very big thing indeed. We found that Barnum's Show was in the town. The thoroughfares were choked to suffocation, and we learned that an army of elephants were momentarily expected along the very streets that we had to travel. We quickly had practical proof that Oxford horses resented the idea of carriages being propelled by petrol, but a few shying horses was a small thing compared with a possible stampede of elephants. The police, however, took our part manfully, and yet more effectually our strident fog-horn cleared the way, and in the end Woodstock was reached practically without stop or stay, and unquestionably in record time.

Professor Tyndall records that "Sir John Herschel in his excellent article on 'Sound' in the *Encyclopædia Metropolitana*, has collected with others the following instances of echoes. An echo in Woodstock Park repeats seventeen syllables by day and twenty by night."

Sir David Brewster states that "Dr. Plot mentions an echo in Woodstock Park which repeats seventeen syllables by day and twenty by night."

Professor Ganot repeats the same story: "At Woodstock Park there is an echo which repeats from seventeen to twenty syllables."

Practically all modern text-books make the same statement.

Arrived at Woodstock Park, there is no difficulty in obtaining direction to the site of the historic echo, nor any doubt at all as to when you have reached it. It is a spot romantic and remarkable enough in itself without its association with any natural phenomenon. It is hard by Rosamond's Well, a handsome stone bridge being on the left as you face the mansion which lies back a few hundred yards and crowns the sloping park. On the right, flanked by fine forest trees, stretches the length of the beautiful lake on the margin of which you stand.

Now blow a blast by the water's edge. Two quick returns come from the bridge, and others lagging crowd in confusedly.

Retreat a dozen paces and blow again. It is better so, and it is better still farther out; but try the gun instead, for the sounds grow feebler and the wind is rising.

So the fowling-piece is brought into action, and a small host of echoes come clamouring back. But where are the seventeen repetitions?

This was the question which again and again occurred to us as we continued our experiments. Carefully the ground was traversed, and trials made and repeated, and in half-an-hour there were half-a-dozen pegs driven in the ground, and marking the spots where the best results had been obtained. Then the heavy artillery was substituted, and from what had appeared the best position a service fog-signal was fired.

The effect was fine, superbly fine, and yet not of the nature to suggest the possible repetition of seventeen syllables uttered by the human voice, let the atmospheric conditions be never so favourable. The other chosen positions were tested in turn, and with like result, and then the final experiment was tried, the grand effect of which could hardly be doubtful.

A service rocket similar to those which had performed so finely on Bucklebury Common was planted near the edge of the lake, and so directed with reference to the wind that bursting nearly overhead it should drop a little way in front of us in the water. Thus the attention would not be distracted by any fears lest by hanging fire the explosions should occur unpleasantly close, and the falling stick would take care of itself. With this small precaution we took up different positions resolved each independently to record our observations, and the rocket was fired.

Being like those previously described over-weighted in the head, its culminating point was reached prematurely, and the charge burst when about 100 feet high and slightly in front as arranged. Surely the echoes of Woodstock had never before been heard as then. Each observer recorded practically the same effect. First the initial report, short and enfeebled by lack of background. Then a thousand echo voices answered nearly together, followed by a few lagging echoes merging in grand continuous reverberations which rolled around and slowly died away. The effect was, as might have been expected, almost the opposite of that observed on Bucklebury Common where near and far objects responded in due order of distance leisurely. Here the early echoes were for the most part massed, leaving a later and feebler roll as of distant thunder behind. Blenheim House with its range of outbuildings must clearly be mainly responsible for these later fainter echoes.

Delightful as the experience had been, there was a feeling of disappointment that the peculiar Woodstock echoes vouched for by so many distinguished authors and so precisely described had certainly not been proved, and for some days I pondered over possible causes of failure without arriving at any satisfactory conclusion, until it occurred to me to consult the older authorities with a hope of gaining further facts.

Dr. Plot, it will be remembered, is one of those who states that the echo in the park repeats seventeen syllables by day and twenty by night. Now Dr. Plot published his *Natural History of Oxfordshire* in 1677, and his observations, which are credible enough, terminated with his death in 1696. I find no other contemporaries of his referring to the same echoes, but in a topographical work entitled *England Displayed*, and bearing date 1769, I find under Woodstock the following: "In this park there was about a century ago a celebrated echo which in a still night would repeat very distinctly eighteen or twenty syllables, *but it has been much impaired by removing some buildings*." The italics are mine, and are hardly needed to show the significance of the passage. The authorities already cited, and others down to the compilers of the most recent text-books, lead us to infer that the echoes of Woodstock are as described. Not one of them confesses that, as in the case of the acoustic effects in the Whispering Gallery of St. Paul's, *they have never been there* to test them accurately themselves.

There is surely here a wholesome caution not to trust even a scientific authority, however eminent, when he is not giving his own actual experiences.

The summer of 1899 continued remarkable for the long duration of a most unbroken fine calm weather, and excellent opportunity was given for prosecuting any experimental work out of doors. It was then in all ways a happy thought which occurred to Mr. J. N. Maskelyne and his son to devote a summer holiday to experimenting in wireless telegraphy on lines of their own. It was happy, too, for myself that I was chosen to assist in these experiments, and to help carry out a new departure in establishing wireless telegraphic communication between an earth station and a free balloon. The experiments embarked on were a revelation to myself, and indeed, in their nature, were completely mystifying.

It chanced that my friend of the Woodstock excursion, the chief of an eminent firm of engineers, came into my library on the morning when Mr. Nevil Maskelyne first brought over his own receiving instruments for some preliminary trials. This was placed at one end of the room, while at the other end, and entirely isolated, a small Wimshurst machine of my own was being worked. As each spark passed between the knobs of the machine the bell of the distant receiver gave a ring in a way that was uncanny, to say the least. But my friend was wholly sceptical. The mere operation of invisible electrical waves across the room seemed incredible, and he suggested that there was some hidden communication by means of the cellar below. When shown, however, that this was not so, he was none the more convinced, having too often been witness of the power of the wizard of the Egyptian Hall to perform wonders, the working of which the world will never be able to divine. And yet the experiment was quite honest, and will be sufficiently understood by a little simple explanation.

The recording instrument comprises what is technically called a "relay." It often happens that an electrical current passing along a wire and meant for telegraphic purposes is too weak to do the necessary work itself, though strong enough to energise an electro-magnet. In other words, it is capable of attracting a delicately-poised piece of steel, and by so doing to close a metallic circuit, which instantly brings into action a local battery able to do the work required. This is the usual device to which the term relay is applied.

Now wireless telegraphy, having but a very feeble current at its disposal, needs a relay of some kind, but since it has no wires to deal with it is made to utilise a secret of its own, recently discovered. The secret lies in the operation of invisible electric waves, which course through space wherever a spark flashes between the knobs of an electric machine or coil. When these waves fall on a few metal filings of a special kind lying loose and disconnected across a tiny gap where a local battery circuit has been broken, it is found that the filings can be made at once to string themselves together into line, and as it were for the moment to mend the wire up. This stringing together or cohering of the particles brings the action of a local battery into play as a relay, and ordinary telegraphic work can in this way go forward.

The apparatus needed for telegraphy of this nature is of peculiar construction, and involves the erection of long vertical wires at both the sending and receiving stations. Such stations were readily extemporised in my own grounds. A spar protruding from the top of the house carried one vertical wire, and a flagstaff a hundred yards away carried the other. And across this interval electrical impulses were sent and received of such power as to show that the apparatus which had been designed for the work contemplated was eminently satisfactory.

A bolder experiment was now embarked upon. A balloon ascent was arranged in the grounds of Shaw House, Newbury, and arrangements were made for the entertainment of the large number of spectators who were likely to come and witness the novel proceedings. Some preliminary experiments of a spectacular nature were designed for the earlier part of the day and successfully carried out. The powerful sparking coil was made to do some of the wonders that have made Tesla's name famous, and a distant wooden structure in which gun-cotton was concealed was blown sky high at the will of a lady who was invited to press the button of a machine which scorned the medium of wires. In all this we had evidence that the invisible electrical waves at command were working to perfection. In the middle of the afternoon, while the July sun was still high, the balloon already inflated was filled with the appliances necessary for carrying out the novel experiment. The receiving instrument was securely fixed to a spar lashed across one end of the car, which was then duly attached to the balloon, while the vertical wires needed were also placed in position.

One of these, that leading upwards, had in the morning been fixed to the valve, and hour by hour had lifted itself into space as the balloon filled. The other wire, coiled up and ready to lower as the balloon rose, had at its free end a tin constantly dropping water, this device being intended to take the place of an earth connection, which of course was impracticable. A hundred and fifty yards away was the wooden hut which contained the sparking or transmitting instrument, and from this too were led two wires, one ascending a pole 60 feet high planted outside, another simply conducted to earth.

The whole apparatus was now complete and in order, and nothing remained but to succeed in getting the balloon well and quietly away, a task not always easily accomplished, even on a fairly calm day. The craft that flies so smoothly and steadily when free is hard to control when in contact with earth. With passengers now inside it has to be duly adjusted with regard to lifting power. So superfluous bags are cast out until the weight is just "off," and at this time a puff of wind will often lift the whole concern out of hand, and let it down again with a jolt that might easily disarrange delicate instruments.

It was unfortunate that a squall at the last moment occasioned some little struggling and confusion and made the release somewhat hasty. The idea which it was our intention to try and work out was that outside our enclosure lay country which was hostile, or from some other cause inaccessible, but which it was the business of ourselves, the ballooning party, to explore. Further, we were to prove ourselves in actual telegraphic communication with our base, testing up to what range that communication held good. It was not desirable on this first trial to risk taking the heavy and costly instruments necessary for sending messages. That experiment could follow later, but we were to receive messages transmitted to us and to indicate that we received them, first while within view by the wave of a flag, and when out of sight by the firing of fog-signals.

At the outset it seemed as if our scheme was doomed to failure, for we soon found that we had got off in rather evil plight. The coil of wire with water dropper attached had got foul and was hanging in an ugly tangle, and though I succeeded in partly rectifying this, there remained more serious trouble, for on switching the receiving instrument into action I discovered that it had been jolted out of adjustment, and was no longer in working order. My daughter and Mr. Simpson had ascended with me, having undertaken the scrutiny of the country, the taking of notes, and, where possible, photographs of important localities, and in these duties they were already engaged. They soon reported that we were over Thatcham, and suggested my firing a salute by way of compliment to our friendly and oft-times helpful neighbours. This I accordingly did, and had scarcely wound in and replaced the exploded cartridge when my colleagues called attention to a striking and significant fact which was not escaping their keen observation.

We had traversed Bucklebury Common, sailing, in fact, over the actual site of our acoustic experiments of a year before, and were already nearing Bradfield College, when our balloon suddenly altered its course through nearly ninety degrees, and headed for Aldershot. Thus, in nautical phrase, Reading, which had been on our starboard bow, was soon on our port beam. The explanation of this lay in the fact that we had slightly increased our altitude, and regarded from a strategic point of view, here was an all-important incident, which might point the way towards enhancing the possibilities of such work as we were that day undertaking. The development of this idea I was destined to follow out later.

We were already six miles from our starting ground, and so far had, owing to the disarrangement of our instrument, received no telegraphic message. I had now, however, a better chance of righting matters. Ballast bags and hampers had been tidied away, and in spite of somewhat cramped quarters order and elbow room had been secured. Inspection showed that nothing was broken in the receiver, only the striker was hard against the bell, and this, with my daughter's assistance, I succeeded in releasing. Immediately, to our intense satisfaction, the bell was off ringing; not very intelligibly certainly, and yet in a way that showed that it was being influenced by the instrument, which was, by this time, miles away and far out of sight.

An adaptation of the Morse Code signalling, which had been adopted by us for our experiments, consisted in causing the bell to give a single stroke for a dot, and a quick double stroke for a dash, and the bell could in no way be made to produce this distinctive double stroke except electrically by the operator. When, therefore, the bell was found constantly ringing three single strokes and then a double, we knew that from the distant station the letter V was constantly being signalled, which is the conventional method of calling attention, and this, in fact, was what my colleague was doing, varying his communication with an occasional interjection.

At six miles then the wireless communication was clearly open, and we estimated that on this first trial the instruments used remained in operation over a range of ten miles, at which distance the receiving station was half a mile high. Flying now at considerable speed, we had Reading a few miles on our left, and soon sighted an array of white tents lying directly in our path and in familiar grounds. For now it was obvious that we were about to pass over Swallowfield Park, where my brother, as vicar of the parish, and a large number of intimate friends, were holding *fête* at an annual flower show. This was a rare and unexpected opportunity for a little genuine signalling of an extemporaneous character, which, wireless telegraphy being impracticable, was conducted thus.

Dipping to a thousand feet as we neared the park, and when in full view of the crowd, we lowered a cartridge in clear space, and fired it the instant we were overhead. This was the salute from the passing ship; and from the land came immediate reply. First the inevitable echoes already described, and then mingling with them the spontaneous shout lustily rendered of a thousand voices. The above little incident made us feel the capabilities of our commanding position, for we completely dominated the mansion and the large gathering beneath us, and had our message been one of war instead of goodwill we could have cast—say lyddite grenades—into every quarter of the grounds below.

Curiously, before the afternoon was spent, we had passed over three other flower shows or beanfeasts, and as many cricket matches, all which events were duly entered in our log, but there were others of greater interest, for we passed immediately over the Royal Military College at Sandhurst; the volunteers under canvas outside Aldershot; the Guards' camp at Pirbright; next the vast cemetery at Woking, and soon after Epsom race course, the grand stand of which was at one moment vertically beneath us.

The towers of the Crystal Palace now hove in sight, and as we approached the outskirts of London I determined on trying the effect of exploding a monster bomb, composed of six fog-signals united. The effect tallied with that recorded by other experimentalists, who have shown that a great increase in the penetration of sound does *not* result from an increased charge of the cotton powder explosive.

As evening was now coming on apace, we decided to land before crowded neighbourhoods were reached, and soon selected a favourable paddock. When close down, however, a heavy gust caused us to swerve towards farm buildings on our right, to avoid collision with which we were obliged to drop ballast and take a flying leap, trusting to what might lie on the other side. This proved to be a corn-field, ripe for the sickle, into which we plumped, rejoicing that, as we did so, we caused but little havoc.

There was, however, little real good fortune in this, for the district was populous, and hundreds of onlookers had for half-an-hour seen us in the sky, and watched us down. So with boldness born of numbers troops of countrymen, just released from work, came charging down, breaking the hedges on all sides and trampling long lanes through the yellow wheat.

Was it just that the voyagers should be held responsible for such damage?

This may be a simple question in law, but in actual practice the question and its answer have sometimes proceeded somewhat thus.

"My friends, do you expect us to pay for the mischief you yourselves have done?" (This said with a heavy bag of ballast balanced on the knee.)

If the rejoinder is friendly, well and good. If otherwise, the bag of sand goes overboard; and then——

CHAPTER XX

IN QUEST OF THE LEONIDS—A RECORD VOYAGE

There has been an old idea common to aeronauts and meteorologists that in temperate zones, at any rate, there is to be found constantly somewhere aloft a wind blowing from west to east corresponding with the direction of motion of the earth's rotation. Green, of early fame, in England, and his contemporary Wise, in America, were both prepared to attempt to cross the Atlantic, so confident were they of being able to find a driving wind. Further, astronomers have stated that bursting meteors will leave their *débris* drifting on lofty currents towards the east.

This fact, if established, has always appeared to myself as one of high importance in connection with ballooning, inasmuch as it should enable the aeronaut to traverse country which defies the ordinary explorer. The trackless wilds of Arabia, for instance, might be crossed and photographed from shore to shore, or a yet bolder adventurer might pilot a balloon of sufficient capacity across the Sahara or the Australian Bush.

Intent on learning more as to the practicability of any such scheme, I made known my readiness to attempt to cross the North Sea by sky passage, and soon received the promise of needful assistance. I then proposed the scheme to Mr. Percival Spencer, who promptly replied in characteristic manner, "I have a balloon doing captive work at the Crystal Palace. Regard it as a cab on the rank. Come up and be ready to start with the first fair wind." This summons I obeyed before the next sun had set, and for a fortnight I took up my quarters outside the grounds, being, by the ready courtesy of the officials, free to pass the turnstiles at all hours, and to avail myself of the first approach of the wind, which it soon seemed we might have to whistle for.

For it was essential that we should start with a wind of sufficient force, and one which was not going to make mistakes. This may soon be seen by a glance at the map. A due west wind should take us to Ostend in 150 miles. This, however, we reckoned but a cockney performance, and not to be embarked upon. A wind from the W.S.W. would land us at the Hague with a rather more respectable voyage of 200 miles. A S.W. gale would make the passage possible, but it would add full another 100 miles, and bring the balloon into the undesirable neighbourhood of the Zuyder Zee, while, if it veered but a point or two more from the south, it would carry us to the coast of Denmark, over 500 miles of salt water.

Here, then, was a programme which was well enough on the map, but the difficulties lay in the equipment. To make a long journey with certainty and safety an ample supply of ballast was needed, it being commonly found that one or two bags have to be emptied every hour, the actual quantity depending on the height at which it is desired to travel, the condition of the varnished silk envelope, the heat of the sun, and other circumstances. It would be reasonable, too, to suppose that all the hours of daylight would be required for the trip, inasmuch as a wind exceeding thirty miles an hour could by no means be reckoned on with any certainty. Thus eighteen or twenty bags of sand would be none too much to start with.

Now it goes without saying that this quantity of ballast, in addition to the weight of two passengers, can hardly be carried by such balloons as are commonly in use, and though we might have every reason to hope that by seeking high altitudes a fast and favouring current might be found, yet using a balloon of only moderate size the attempt would be attended with too great risk if there were not a lower wind which we knew all about, and of which we could always avail ourselves.

Daily, then, and anxiously, through forenoon hours, we watched the trend of upper clouds, but only on three occasions did they give us reasonable hope of accomplishing our object. On two of these ere our preparations were complete, the wind, as so often happens in fine late-summer mornings, veered towards the north out of the required direction, and the attempt was abandoned. On a third occasion all things seemed to favour the venture, which was therefore determined on as soon as a brief lull occurred in a wind that blew in gusts of half a gale.

Unfortunately, the mooring ground of the captive balloon was not that of the sheltered balloon-ground of the Palace, and at the moment when Mr. Spencer and myself were endeavouring to embark a strong and sudden gust swept the ground and carried everything before it, the combined efforts of the staff of assistants notwithstanding. Ropes and netting immediately gave way, and the balloon would have become an entire wreck had it not been promptly emptied.

About the same date I met with a further disappointment of a similar nature. This was on the occasion of the garden party given in the grounds of Dover College in honour of the meeting of the British Association. It was arranged that I was to carry out an ascent with the hope of being able to make trial of the penetration and reverberation of cotton powder fog-signals fired over the sea. Of course, I had no right to be disappointed if the right wind did not blow, but it did.

At 3 p.m., when the balloon was fully inflated, the flag on the castle was flapping bravely out to sea, showing a current high enough and strong enough to insure our reaching the French coast in two hours. But the guests as yet had hardly arrived, and the balloon as the chief attraction should be kept till later on. And so the ascent was postponed till 5 p.m., by which time the wind had dropped almost entirely, and the flag on the castle hung limp around its halyard. But what was worse, there was still a slight air blowing off the land, just sufficient to drift us out over the sea, into which we must eventually drop. Thus a second time a trip across salt water was, as it were, snatched from my grasp, and as the season was now drawing to an end there seemed little likelihood of any opportunity of retrieving ill fortune.

Such an opportunity came, nevertheless. Only two months later I was destined to take part in a voyage which, in its way, is without a parallel in the annals of English ballooning. November 14th, 1899, had been the day looked forward to for the third part of a century as the date on which might be expected the return of the great meteoric shower radiating from the constellation Leo; which shower for hundreds of years has displayed itself to our planet three times in every century. True, it might have been considered due the year previously, but the very fact of its non-appearance made it the more probable—many would have said certain—to manifest itself in the following November. Among astronomers, the chief doubt entertained was as to whether the shower would reach the earth while it was night (and the "radiant"—the point in the heavens from which the star-shower seems to issue—above the horizon) over the British Isles, and in this case whether that night would be the night of the 14th or of the 15th, or possibly both. Any way, the greatest disappointment would be occasioned if the shower should occur as foretold, but fail to be observed in England by the mere intervention of clouds.

To avoid such mischance I entertained the idea of arranging a balloon ascent which would afford me the means of piercing any clouds that might obscure the sky. Even in the event of a clear night on the ground an altitude of a few thousand feet above the heavy strata of atmosphere usually lying low in a November night would give me, as an observer, a great advantage. For I had already learned how greatly elevation above earth's surface improves the seeing in the case of faint stars on a moonlight night, and on the nights of the expected shower the moon would be near the full.

As to the instability of such an observatory as a balloon, there was little or no objection in this, inasmuch as no instrument was needed save perhaps a field-glass, which could easily be steadied by the hand alone.

Submitting my ideas to Mr. Moberly Bell, the manager of *The Times*, I was happy to find that one whose judgment is so universally to be relied on regarded the project with favour, promising moreover his co-operation if I could make arrangements for its due accomplishment.

My next step was to take counsel with my friends in the astronomical world as to how I might best fulfil my mission. And here I naturally met with much more guarded replies, for in truth the most recent calculations had shown that the time when the earth would encounter the denser portion of the meteoric stream was practically an unknown quantity. This may be easily understood. The meteor track is an orbit in the form of an elongated ellipse, the further end of which reaches to the confines of the solar system, while its nearer end bends close round the sun. Around this track the meteors travel in extended order, completing the whole circuit in about thirty-three and a-quarter years, or almost exactly three times in each century.

Now, it chances that the earth actually meets this meteor track about the 14th of each November, and crossing it in a slanting direction occupies some hours in so doing. There is thus, as it were, a level crossing common to earth and meteors, and, arguing from the data supplied by bygone observations, the meteor train in its due time should be sure of coming into collision with the earth, inasmuch as it occupies more than a year in dragging its long length past the crossing. So far all seems clear, but there have to be taken into account other considerations which are capable by lapse of time of altering the circumstances of the case.

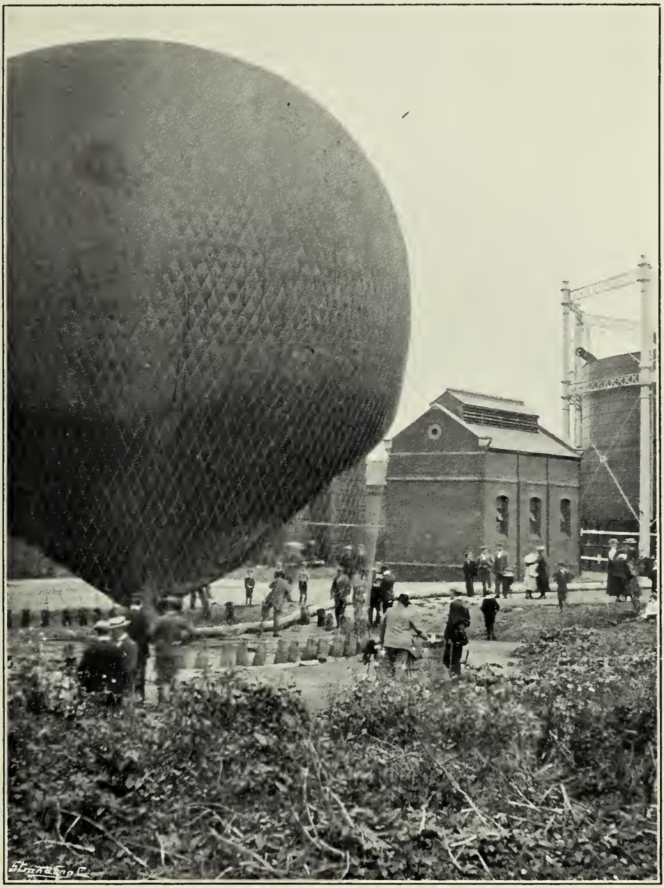
Thirty-three and a quarter years is a long interval, long enough for much to happen affecting the delicately-balanced constitution of a train of tiny meteors which are constantly under the disturbing influence of giant planets, travelling comparatively near their own course. At any rate, facts which had recently come to light caused practical astronomers to fear that the Leonid meteors had suffered serious perturbation. The right advice seemed to be that I should have a balloon moored and kept in readiness for eight-and-forty hours if necessary, so that if on either of the two nights thought to be possible for the event the right moment seemed to have arrived, we could at once sail skyward.

On consulting with Messrs. Spencer as to the feasibility of this proposal, it appeared absolutely necessary that our balloon should be fitted with a special valve for the occasion. The ordinary valve could not be relied on to prevent material leakage of gas during the long period that the balloon might need to remain inflated. This form of valve, well named the "Butterfly" valve, consists of two-hinged shutters opening with a pull inwards, and returning when released to their closed position by means of a spring. This valve, admirable for regulating the discharge of gas, was ill-adapted for the purpose in hand, inasmuch as no amount of luting could insure its joint being perfectly gas-tight.

Another form of valve, however, known as a "Solid valve" would obviate this difficulty perfectly. This valve is really an entire piece of fabric varnished like the silk of the balloon and bound hard and fast over the whole upper opening. This would absolutely defy all leakage, while it possessed one small drawback only, viz., that it could only be operated by being torn wide open once and for all when the balloon had descended near the earth.

The early days of November gave no particular promise of fine weather, and in England at least people grew anxious about the chance of witnessing a spectacle which had been looked forward to through a whole generation. Clouds, however, possessed no terror for ourselves; only the wind made us apprehensive. A breeze of merely 30 miles an hour might bring us near the sea and terminate our observations before two hours were passed. As to preparation, little enough was needed. A little fresh practice in star-charting, and a few nights spent in making oneself thoroughly familiar with the neighbourhood of the radiant point in that portion of Leo known as the Sickle was all that was required.

On the 15th of November Mr. Stanley Spencer arrived at Newbury with a 56,000 c.f. balloon, and towards evening commenced its inflation in the enclosure of the town gas-works. The night set in calm and fair, and presently the stars twinkled out, but as the radiant did not rise above the horizon till about midnight it was just as well to take matters calmly, and so the balloon, now full, and carefully secured by equatorial lines, was left in practical readiness and under due custody, while the aeronautical



(From a Photograph by Miss G. Bacon)

FILLING THE BALLOON AT NEWBURY

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party returned to my own house for such rest and refreshment as circumstances would permit of. This party numbered three in all, it having been arranged that my daughter should take part in the proceedings as chief assistant.

By 11 p.m. it was seen that the rising of the radiant was not being heralded by any meteors, and soon the familiar Sickle showed above the horizon, looking very much indeed as usual. Still the coming of the shower was practically due at any time, so the night was divided into watches, and all the time my motor car was kept in readiness in the coach-house, capable of being started at a moment's notice, and of covering the four miles that lay between us and the gas-works in fifteen minutes.

It is ancient history now that the Leonids never came that night, but this was only the greater reason why the strictest watch should be kept all through the night that followed. And to the observer below this was fruitless work as the sky was shrouded with cloud — dense and heavy cloud — cloud everywhere over the British Isles, save only in one or two favoured and restricted districts. So still, too, was the night that there seemed no prospect of the stars breaking through anywhere. Under these circumstances the right course to pursue clearly was to avail ourselves of the advice based on the most reliable computation that had been made, and according to this advice the start should be delayed till 4 a.m. if nothing happened in the meanwhile. A false start in a balloon is fatal from the fact that one cannot start afresh. As, moreover, on a cloudy night like the present, some two hours would be the limit of time which safety would allow for our voyage, it was deemed on all hands advisable that the two hours chosen should be those immediately preceding the dawn. The chances then were considered at their best; the radiant would be high in the sky, and the moon, far too bright for good observing, would be near her setting. Our programme, then, excellently arranged for us by an able and voluntary staff, was—to reach Newbury at midnight; to complete final preparations for an immediate start at any moment; to set a watch who might report any break in the sky; and ourselves to remain within easy summons.

We retired to rest from 9 p.m. to 11, when we partook of supper and then drove into the gas-works, where a dense crowd was collected determined on waiting and watching the night through till the balloon should ascend. We then took up our quarters at the Newbury Guildhall Club, who kept open house that night on our behalf.

The character of the night remaining unaltered, we waited till 3.45 a.m., when we repaired to the gas-works, and so admirably had all been organised that the departure was effected as readily as if we had merely been leaving by our own private carriage. As we arrived in the enclosure the steam-hooter of the works was, evidently by pre-arrangement, set sounding for five minutes, and this signal enabled a vast number of neighbours to indulge in the general desire to witness the start of the night balloon. At this time the air was moderately cool for a cloudy November night. The breeze was light, but owing to the darkness we had no guide as to the direction of wind currents overhead.

Having bestowed ourselves and our belongings comfortably in the car, fourteen sandbags were counted to our credit, and we at once cast off amid deafening cheers. As these died away I shouted back, "Which way are we drifting?" and a voice answered, "Due west." A minute or two later, I blew a blast on a horn as farewell. These, I believe, were our last communications with earth during a voyage exceptional in the annals of English ballooning for duration and peril. I remember seeing far down the streets and open squares of Newbury, dimly lit and difficult to recognise. I also remember a little later a wide red glare over the town, already well in our wake, and then we entered the cloud, from below which we were not to emerge again for many long eventful hours.

While yet in the cloud we heard some stable clock below us striking quarters. At that time my sensations were those of being in a warm steam bath. My beard and moustache were dripping with moisture, and I threw open my overcoat to mitigate the effect of the oppressive air; and we remained long in these conditions.

Picture a wicker basket floating in blank darkness somewhere over the Kennet Valley at 2,000 feet above the earth, with a Davy lamp dim and nearly blotted out by the fog, dangling from seemingly nowhere, serving only to make the pitchy blackness all around more apparent. This was the extent of our visible environment. True there was light enough reflected from close objects for us to see each other's faces and to read an aneroid, which showed an altitude all too slowly augmenting. We had but risen 500 feet since the cloud was entered, and no less than three bags of ballast had already gone overboard, although we started with abundant lifting power. And there was no chill in the air to cause the gas to shrink. Was anything wrong? A brief consultation satisfied us all that our lack of buoyancy must simply be due to a large accession of condensed moisture. The balloon in consequence of having been moored for hours below had become reduced to the temperature of the cold night, and now in the warm, wetting fog, its large surface was becoming so heavily dewed as to gather great additional weight.

Another bag had to be emptied, in response to which the balloon sluggishly gained another few hundred feet. But then it paused, and in a minute or two began slowly giving back. Our aeronaut's face grew serious. They were heavy bags, but we were losing ground again, and another must be sacrificed, although the expenditure was far too rapid to be entirely safe under our peculiar circumstances.

Five bags altogether were parted with in fifteen minutes; and now at last we noted the encouraging result that the balloon was climbing steadily, and the mist already thinning away. Indeed, we were for a few seconds completely through the cloud and able to look around. In those few seconds not a meteor had been glimpsed, though all the region between Leo and Orion had been clearly visible. This was disappointing, but a far greater disappointment was our falling back into the fog again. The reason of this was obvious; for now in the upper margin of the cloud the air struck keenly chill and the cold had crippled the balloon and sent her down. At my earnest desire, therefore, and in spite of his better instincts, our aeronaut discharged another bag, and once more we gained the clear, getting so well above this time that we could take a longer survey of our new position. It was now apparent that the Leonid shower was not in progress, though one or two stray meteors coming from the true radiant gave a faint hope that its approach might be expected. In but a short while, however, we had dropped back again into the cloud, and the mist once more closed over our heads.

I must take my full share of blame for what followed, though I must at the same time urge in my defence that I felt I had been sent up to observe the meteors, and that at all hazards I should not turn back till my task was completed. Moreover, I may state that the ultimate consequence of the rapid loss of so much ballast had, probably, hardly yet occurred to any of us. At any rate, I it was who urged the discharge of more, and accordingly another bag was emptied into space, making seven in twenty minutes. We now remounted till we reached a level slightly above the upper margin of the cloud, and at that height we remained.

Mr. Spencer's next action was to put on his coat, somewhat promptly. There was no need to ask why. The air was intensely cold. As already stated we had found it by comparison extremely warm in the heart of the cloud, and it will presently be told how we found another warm region at a somewhat *higher* altitude. At our present level, however, we felt the cold keenly, and this fact was undoubtedly due to the evaporation going on around us. It is well known that moisture in the air greatly aggravates the sensation of heat—as in a greenhouse. The same is true with regard to cold. While on a recent visit to the Yerkes Observatory, Professor Barnard assured me that when observing on a clear winter's night, with the thermometer about zero, the cold was, to use his own expression, "murderous," but when the thermometer sank another 20° or more the moisture became frozen out of the air, and then the cold was more bearable. But it is also known that the very process of evaporation induces cold in surrounding objects, since heat is essential to the formation of vapour. A confusion, perhaps, exists in the minds of many people as to what is implied by vapour, which, properly speaking, is a term simply applied to an easily condensible gas. It is common to speak of seeing the steam of an engine, and yet steam is never seen. The wreaths of mist that trail behind a steam-engine are water pure and simple condensed from invisible steam. In our case, however, the opposite process was going on. The water of the mist around us was evaporating into invisible vapour, and drawing out of the surrounding air the heat necessary for this purpose.

That evaporation was going on now around us on a gigantic scale was made very manifest. The surface of the vast cloud floor below us was in a perfect turmoil like that of a troubled sea. If the cloud surface could be compared to anything on earth it most resembled sea, where waves are running mountains high. At one moment we should be sailing over a trough wide and deep below us, the next a mighty billow would toss itself aloft and vanish utterly into space. Everywhere wreaths of mist with ragged fringes were withering away into empty air, and more remarkable yet was the conflict of wind which sent the cloud-rack flying simply in all directions.

It was this cloud sea which we were destined to have leisure to observe narrowly and anxiously through many long hours, and we were able to note much that is interesting and instructive with respect to those dense cloud coverings with which we are so familiar in England, but which we generally have opportunities of observing from the earthward side only.

Another reason for the coldness of the free upper portion of the cloud, of course, is that ascending currents become chilled by mere expansion into regions where the pressure is less. At 4,000 feet, where we were at the period now being considered, the pressure is very appreciably less than on the ground, and our attention was called to this fact incidentally in a curious manner. Stimulated by the keen exhilarating region in which we found ourselves, our thoughts turned instinctively in the direction of breakfast. True, it was scarcely yet five o'clock, but we had been up all night and our sandwich basket had a tempting appearance. Our only beverage was a modicum of stout in rather a large jar. Thus within the jar there was a large portion of air remaining at the pressure which it had when bottled off at the earth's surface, while the aneroid told us that the pressure which at starting had been that of a column of mercury of 30 inches was reduced to that of a column of 26. I forgot this for the moment, however, as I proceeded to tug at what appeared to be a tightish cork. What followed took us all by surprise, for the cork flew out like that of a soda water bottle, and with a report which was startling enough in that silent region.

Of the meteors there was unfortunately little to record. All that we observed were duly charted, but they made a sorry display, no better than may be seen almost any year on the same night. The main difference was their brilliancy, for all the stars, as on other night voyages, were intensely bright. Sirius winked all kinds of blue at us, but so keenly as to make the eyes ache to watch him. One heavenly body, however, was at a disadvantage. The moon was fast getting down in the west, and shone gloomily through moisture-laden beds the colour of deep red copper. And presently a curious sight was afforded us. For she went down, disappearing with a strange unearthly —I mean unmoonly—visage, and with one last forbidding look, as though warning us to mind what we were about. And then directly after, as if in fulfilment of her warning, we began mysteriously ascending into the sky, so that presently on turning about we found the moon was up again, having risen once more entirely on our account; after which she quickly set as before and with the same sort of look, as much as to say, "I told you so!"

We were soon to learn what she meant.

I have forgotten to mention that the moon had half-an-hour before afforded us another wonder-inspiring spectacle, not infrequently noticed in night voyages among the clouds. We were at the time only just above the banks of white wet mist, and the moon shining with considerable brilliancy upon us threw a monster bright circle on the cloud upon which was displayed a gigantic shadow of our entire balloon. No Brocken Spectre on the Hartz mountains could appear more strange and weird, for there was a phantom car with three ghostly occupants staring at us out of the bosom of the cloud, and mimicking all our gestures. And then it might be seen that the centre of the great spectral circle was exactly occupied by the eye of that particular ghost, which was representing one-self.

At about half-past five, while it was yet dark, we distinctly heard the clatter of hoofs of a horse being trotted briskly along a hard road underneath. Our aneroid told us that the road was fully half-a-mile below us, and what was very noticeable was the fact that though the rumble of the cart was audible it was not nearly so distinct as the footfalls, proving what I have often called attention to in these pages that high pitched sounds carry farther than those that are lower. At close range it is the lumber of the cart which seems the louder sound, but for all that it is the sharp ring of the iron shoes that penetrates farthest.

Another point noticed about the trotting horse was that it seemed to keep pace with us, as though we were going the same road. Later on we heard a train also immediately below us, and at ten minutes to six we heard another horse trotting—or possibly the same; from all of which we inferred that we were over the

Bath Road and had been following its direction pretty closely ever since the start. This has since appeared the more probable from observations made on a subsequent balloon voyage in daylight, when we again started from Newbury gas-works and took the same general direction. On that occasion our balloon, which first took a different course seemed attracted to the Kennet Valley, the course of which it followed for many miles, and this gave me the impression that an air stream will follow the course of a river valley even at many hundreds of feet above the river's bed. Now the great road, the railway and river, all follow up the course of the valley.

At 5.55 a shrill hooter blew below us, sounding on incessantly for five minutes, when it ceased, and immediately a familiar clock-bell struck the hour. Both sounds made me morally certain that we were then over Hungerford. Then, two minutes before the hour, the dawn broke, and I am fully justified in being precise to the minute. I cannot recollect in any part of the world, including the tropics, having ever witnessed a more sudden dawn, due, as I imagine, mainly to our being now above that part of our atmosphere which by refraction and reflection gradually forestalls on earth the coming light of the sun. Be that as it may, the light of the dawn was altogether unusual—a pale green, with a copper-coloured flush on the horizon.

Altogether the appearance of the setting moon and of the rising sun had been reminding us of those risings and settings which characterised the period immediately following the great eruption of Krakatao, when a vast dust canopy at an enormous height was supposed to be hanging over more than half the globe. The question then occurred, Were these same peculiar hues, now being manifested in our clearer sky, due to the presence of unusual dust lying in the far heights above us? Or in other words, was there the presence up there of the *débris* of meteors which, too inconspicuous to be noticed on earth, had nevertheless entered our atmosphere?

Now a suggestion had been made to me that I should make experiments to test if meteoric dust were floating at such altitudes as I reached; and I was resolved to carry out a method which Professor Ramsay had proposed to me, and which consisted in using a special form of pump or syringe, by means of which copious draughts of air could be drawn through a plug of gun-cotton. In passing through this material anything of the nature of fine dust would become entangled in the fibres, and entrapped in this way could be brought down to earth for examination. The rest of the process is as simple as it is beautiful. On the gun-cotton was to be poured sulphuric ether, which would at once reduce the whole mass to collodion, in which there would still remain the meteoric dust if any had been caught. In this case it will be seen that a drop of the collodion would merely need to be placed on the glass slide of a microscope, when the matter to be scrutinised would be quickly fixed in a medium admirably adapted for its examination.

As a matter of fact I did most energetically inspirate gun-cotton in the upper regions in the manner proposed. I have that gun-cotton still, but have never dissolved or examined it, having become firmly convinced that no trace of matter from meteors falling that night could possibly have found its way within. I shall show later that a floating body which I presently dropped from the balloon at a height of two miles took nearly as many hours to reach the earth. Seeing then that meteors are supposed to burst at perhaps fifty miles in the air, it is impossible to conceive that mere impalpable dust proceeding from them could settle to the earth in a single night.

A very few minutes after the dawn had broken for us we heard a prolonged crowing of cocks, and I think the noisiest I have ever heard. No doubt they were heralding the break of day, and from our point of vantage we could hear them joining in from all the farms over a very large area. To them, however, the dawn must have been dull and cheerless enough, for 1,500 feet of dense cloud was everywhere shutting out the light which with ourselves was already that of day.

In the last quarter of an hour we had risen several hundred feet, and now were in an atmosphere considerably warmer than at the lower level when in close proximity to the evaporating surface of the cloud. By this time, too, it was broad daylight, so that there was no object in our remaining longer aloft, and we accordingly packed away note-books and opera glass ready for the time when we should begin to descend; and having busied ourselves thus for a little while we consulted the aneroid again, and found ourselves somewhat higher than before.

Unfortunately, I have no entry among my memoranda as to the moment when the sun rose. It was considerably earlier, of course, than the time given in the almanac, and it would be interesting to know how much or how little in our case refraction hastened its appearance above the horizon. I can only relate that its first peep above the distant edge of the cloud-plain was a superb spectacle attended with atmospheric effects of rare beauty, and unknown in any previous experience of my own. We gazed on it all with ecstasy for some minutes, after which we again looked at our aneroid and found that we were *considerably higher than before.*

It was now that there dawned upon us a conviction to which we had for some time been shutting our eyes. There was no use in disguising the fact any longer; we were caught in a trap! We had parted with our ballast far too prodigally under the peculiar circumstances in which we were placed. It will be remembered that we had a solid valve which, admitting of no ordinary manipulation, could only be opened wide once and for all when within safe proximity to the earth. But we were at this moment fully 5,000 feet above the earth, and over a region of which we knew absolutely nothing. Clearly, under present circumstances, it would have been madness to tear open a gaping hole of two or three feet across in the top of our balloon.

What, however, was the alternative? Simply to wait until the balloon came down of itself; and this, under ordinary conditions of balloon travel, would have been well enough. For in almost all cases balloon ascents take place in an afternoon, and then of necessity the sun presently declines, the air grows chill, and the balloon infallibly begins descending. But now with us the case was exactly the other way, and the sun was beginning to rise—and to rise, too, from our point of view, in an unblemished sky without the thinnest veil of cloud anywhere to mitigate the fierce rays which in our rare air would soon beat down upon us.

The first and most obvious effect of the sun was that it began to dry our balloon, the whole surface of which held as great a weight of moisture as it could contain. This made us rapidly lighter, and sent us hurrying upwards. But the sun's rays acted in another and yet more powerful way in accelerating our ascent by warming the gas. Every aeronaut learns to appreciate the extent of this heating just as every cricketer learns how intensely hot it is inside a marquee on a sunny day. The heat in each case is an accumulating heat, like that in a greenhouse.

In this last case the increase is due to the peculiar properties of glass which allow certain heat rays to pass, but not others. Heat comes from all parts of the visible spectrum, and most of all from that part which, lying outside the red end, is to our eyes invisible, or as it is termed obscure. Now the obscure rays cannot penetrate glass, while the bright rays can, and this fact is made use of in glass screens which are potent to mitigate the excessive heat from a fire-place. In a greenhouse, therefore, the bright rays, visible to our eyes as light, enter freely and warm all objects within the house, which in their turn radiate back the heat they receive. But this radiant heat no longer consists of visible rays, and is therefore unable to pass out of the glass again, and thus the heat goes on accumulating. In a very similar manner the heat of the gas inside the envelope of a balloon goes on augmenting in sunshine, in spite of the fact that the outside air may be extremely cold. Many a time in my experience a voyage which has seemed to have reached its limits from the expenditure of all ballast has been extended for an hour or more simply owing to the sun's coming out.

It was the aneroid now that received our chief attention, and from it we learned that we were mounting upwards at the rate of about 1,000 feet in every twenty minutes, and this ascent continued until we had attained an altitude of 10,000 feet, or nearly two miles above sea-level.

The significance of this was only too apparent. We had already been up longer than the time which we had considered it safe to remain aloft, and yet it was clear that many hours must elapse before there would be the least chance of our settling earthwards again. We knew, and should continue to know, absolutely nothing about our whereabouts. All that we could tell was that we were in all probability travelling west, and a due west direction would take us to the sea in 60 miles. There was of course no means of judging the speed of the current—now a lofty one—by which we were being borne along, but these high currents very often blow at 30 miles an hour, so that were we to remain up till the sun began to decline we should at this reckoning be carried far out to sea.

We were fairly and hopelessly cornered, and the peril of our situation was fully brought home to us; and yet it was impossible to feel unhappy! We were in such a joyous region with the bright warm sun and the exhilarating air, and with such a world of wonder below us as few can have ever seen. The cloud-floor which at closer range had seemed so broken and tossed with billows was now at a full mile below us spread out like one vast field of closely compacted snow, dazzling white, and stretching on into infinite distance. Here and there its otherwise level surface was broken up into forms vaguely resembling familiar features on earth, a river's bed, spires and domes of some aerial city, and in one direction and not far away the most realistic presentment of high rocky cliffs and, beyond, the open sea.

An hour before, when as yet we were only climbing through lower levels, we had listened with all our ears for such sounds of earth as would assure us that we had not yet strayed beyond the limits of the land, and for a long while we could detect the rumble of trains, the report of guns, and yet more frequently the sounds of a farmyard and the lowing of cattle. Certainly I never learned before what music for one's soul could be imparted by the bellow of a cow or the braying of a cheery jackass. Now, however, we were removed from all ordinary sounds, and for a long while had no clue as to whether we were over land or had already passed out over the Atlantic.

In this plight someone suggested, what was sound advice, namely, that we should have lunch; and though the sandwiches had too much sand about them from contact with the ballast and were growing dry withal, and though our slender store of stout ran low, yet we enjoyed a hearty not to say a merry picnic in our little wicker basket hung in space. One of us essayed a verse, thought to be appropriate, of "For I dearly love the sea," and our meal was becoming marked with much hilarity when my cap got knocked off my head and fell overboard.

I have often wondered what went with that cap, and have asked in likely quarters and enquired through local papers, so far without result, but I can imagine what *might* have happened. I can picture a countryman digging in his garden or maybe sitting on a three-legged stool milking a cow, when piercing the high clouds above him a tiny black speck appears, and speeding downwards with the velocity of its terrific fall lands beside him as out of heaven—a yachting-cap! Such an apparition would set many a country friend of mine thinking as he seldom troubles to think.

My misfortune was greater than might be supposed, for I had no spare cap, and the sun was now blazing down fiercely. So trying indeed was the heat at this time that we tied cloths and scarves round the rigging as protection while I knotted a handkerchief about my head and tried but vainly to think that it was only a November sun after all. Then we told tales and talked of the startling telegram which we should have to send to the *Times* if only that telegram ever got written, and then we wondered if three individuals were ever in such a case before, and what interesting photographs we might take of ourselves just then if they were only ever developed. Anyhow the idea appeared a good one and worth the experiment. So two of us would put our heads together as far over one edge of the car as possible while the third retired out into space in the other direction as far as holding on by the rigging allowed, and thus we took snapshots, and these monstrosities of portraits are still preserved.

And in the middle of it all, suddenly there came among us, whence we knew not, a strange visitor. A big bluebottle fly buzzing and fussing about as though claiming a right to look around. It was our impression at the time that the creature must have been brought up with us concealed in the folds of a cloth or elsewhere, and that the hot sun had enticed him from his hiding place, for it was contrary to all our experience to find insect or bird life at such an altitude as ours; moreover, it was hardly the month of bluebottle flies.

On this matter, however, I have received a very interesting communication from Mr. F. T. Wethered, of the Alpine Club, who states that he has seen a butterfly scudding along the summit of the Grandes Jurasses at a height of 13,799 feet, and sees no reason why the fly should not have been on the wing.

CHAPTER XXI

HOW WE ESCAPED

In the earlier part of the morning our balloon had been apparently haunted by a ghostly visitor; we were then some few hundred feet above the cloud-floor, which however (there being no guide to distance) seemed almost at our feet, with a surface which looked as compact and hard as an ice-field. Our limbs were getting cramped with sitting in confined quarters, and the idea rose in our minds that we might step out and have a run round for exercise. And just then as if to lure us to such an act of folly we heard repeatedly the sound of someone walking softly outside. The explanation of these mysterious sounds was presently traced to the moist shrunken netting giving out under the hot sun, and yielding now and again with gentle release to the expanding gas.

It was a little before noon when the dead silence which had so long reigned, was at length broken by the scream of a locomotive, followed by the rumbling of trains as though from some important railway centre, and immediately afterwards the crash as of heavy hammers could be heard. This led us to the conviction that we had reached the town of Bristol, and if this were so our case was surely growing desperate.

But then a bright idea occurred to one of us. Needless to say it was to the lady of the party. There was possible help at hand if we could only communicate with the people below us. Surely we could convey a message to them and bespeak their assistance. At any rate, the attempt was worth making. I had with me a large bundle of press telegram forms, ruled on one side, but plain the other. These would serve our purpose, and so, with ready despatch, we put into execution a system of aerial telegraphy, certainly unknown in history.

We hastily wrote out the following message, repeated on some three dozen forms:—"URGENT. Large Balloon from Newbury travelling overhead above the clouds. Cannot descend. Telegraph to sea coast (Coast Guards) to be ready to rescue." As the writing of each message was completed the paper was neatly folded into a three-cornered note, with the word "IMPORTANT" writ large in red chalk upon it, and then dropped over the car.

The work was carried out by all three of us with a proper division of labour, but before it was completed we all instinctively desisted, and craning our heads over the edge of the car listened attentively. There was no need to tell what sound it was which we each seemed to hear. From far below us, subdued but distinct and unmistakable, came the regular plash of waves upon a pebbly beach, and as though to dispel all doubt there followed the doleful wail of a steamer's siren.

There can be little doubt that the majority of our missives dropped in the sea and were lost. One, however, was picked up after an extraordinary journey, of which I shall speak presently.

The writing and despatching of our messages had necessarily occupied some considerable time, and claimed all our attention, and we had therefore neglected to keep an eye on the aneroid. Great was our astonishment then on again consulting it to find that it indicated a drop of more than two thousand feet since last examined. As to the cause of this we have since been satisfied. We have found that at the time referred to we had reached the mouth of the Severn, over twenty miles of which we then proceeded to travel. And up this arm of the sea a colder upper current must have been blowing. The returns which I have received from the meteorological office show that at the level of the earth there was a different drift of wind prevailing at this time over South Wales, and that during the mid-day hours the wind was blowing in that region with increased force.

Anyhow, it must have been about the hour of noon that, unknown to ourselves, we encountered a cold stream, which, crippling our balloon, caused it to commence descending in spite of the heat of the sun, then at its meridian height. Our downward course was not well maintained, owing probably to the colder currents being but shallow, but in half an hour we had crept down sufficiently to be once again within range of sounds from earth, which assured us to our relief that we were now again over open country.

The first drop ended, our balloon seemed to recover fresh life, striving stubbornly to maintain its height, and at times even to increase it. Indeed, the entire descent from this time was marked by a series of fluctuations, such as I had never observed before in a balloon abandoned to itself.

So bravely did the sinking ship struggle, disputing every inch of its decline, that a full hour elapsed before it had sunk finally to 4,000 feet, and so remarkable was each fall and rise that we took to entering them in our note books. The readings abridged run thus :—

4,900, 4,800, 4,900, 4,800, 4,100, 4,300, 4,000, 4,150, 4,000.

When we had fallen to about 4,000 feet our attention was drawn to the surface of the cloud-floor, which was now about 1,000 feet below us, and which had greatly altered in appearance since we had observed it from the same height several hours before. It was now looser in texture, and broken up here and there into deep hollows, much as a snow field will become broken up under a hot sun; and these hollows were, for the most part, a dark grey, sometimes, however, assuming a ruddier hue. It was a beautiful and wonderful spectacle, and Mr. Spencer remained gazing down at it long and intently with his head bent over the side of the car and his cap off.

Suddenly he called out, "I see a church down there!" Now a church was quite the most unlikely object for him to see in the wild wilderness of cloud below, so that I felt sure my friend's mind was affected, and that he must be suffering from sunstroke. I therefore endeavoured to persuade him to withdraw back into the car. But he insisted on remaining as he was, and presently exclaimed again, "There's a village and a road!"

And he was right. One of the dark hollows below was for a moment bridged over by a faint white thread which glided past. The hollow was actually an opening in the cloud floor, and through it in the abyss below we saw familiar objects sliding by.

Evidently the cloud, which in the morning was 1,500 feet deep, had thinned away to a comparatively shallow layer, and was beginning to break up. Two facts also were already revealed to us by the little we were able to glimpse through the opening. First, the rich red soil—which had made the cloud hollows look ruddy—betokened that we were over the south-west corner of England, or else South Wales; and secondly, that we were now travelling very fast, for the ground, in spite of distance, swept by rapidly.

This made us doubly anxious to descend, for we must surely by now be near the coast. It was a terrible race. We had been a whole hour climbing down to our present level of 4,000 feet, but we knew that if we could but reach the cloud layer we should then be shielded from the sun's rays, and our fall would soon be rapid. Maybe, we should have abandoned all hope had we known at that time that we were yet to be nearly another hour before we sank to earth. Our noble balloon was dying very hard.

Again we watched the record. Down to 3,900, then long remaining at 3,800, next with a swoop down to 2,800, but recovering immediately another 100 feet, after which once again we came to a dead-lock. As to the chances of our being picked up alive in the event of our dropping far out at sea, it was impossible for us to be in the least sanguine.

It so happened that we had bespoken a large lifebuoy for our safety in case of emergencies, and this had actually been placed in the car before leaving Newbury. But it proved heavy and cumbersome, and the night being calm the idea of wanting it seemed too absurd, and we left it behind. We should now have valued it above all our possessions. True, we could all swim, and the balloon itself would probably float for a considerable time, but in the water it would only prove a mere death-trap by reason of the large loose netting which would lie around it, and entangle any swimmer who endeavoured to cling to any part of the floating gear. Of course, we might be sighted, and a balloon in distress at sea would be an object which any vessel would attempt to save; but, as a matter of fact, balloonists have been drowned within full view of land and with boats hurrying to the rescue.

After a while we lost sight of earth again, the mist thickening below us, and our stock of hope and patience might have well become exhausted only that we possessed other evidence beside that of the aneroid that our relief could not now be long delayed. The sun, clearly lower in the heavens, began to look at us more aslant, and the silk above us, hitherto tense and glistening, showed signs of puckering into wrinkles.

And so little by little, by insensible degrees we crept down, or rather it seemed as if the mist crept up, and presently a huge wave rose and swamped us, cutting off the sun for a brief interval, and then the next moment the billow rolled away and left us in the clear once more. This happened many times with lengthening periods of obscuration till in the end we rose above the fog no more. The fierce rays of the sun were now cut off, and the cooler temperature of the cloud came to us as a grateful relief. The balloon, too, soon showed signs of yielding to altered conditions, and little fragments of paper tossed out would hover for a moment like butterflies and then flutter upwards. The end was coming near at last.

After no long delay, dropping rapidly, we suddenly emerged through the cloud ceiling, and were back in the world again. Below us lay a wild romantic country, mountains, woods and water, patched with cultivated fields. Clearly we were coming down in a land of mines, and almost directly below us yawned the awful mouth of the Cwmavon Stack. But formidable as this might appear to visitors arriving by balloon, there was an object hard by that had far greater terrors.

Only one and a half miles off lay the broad sea, the vision of which had haunted us for hours, and which was now so narrowly missing capturing us. But from that our worse peril we saw that we were already safe. For we were coming down with unusual and increasing velocity, and but for the close proximity of the sea a liberal discharge of ballast would have been resorted to.

It has already, however, been pointed out in these pages that towards the close of a sky voyage a free discharge of sand will often impart a giant stride, sometimes of several miles, to the dying balloon, and anything of this nature could now on no account be risked.

We therefore came to earth with great violence, and ere we were fairly down saw that we were caught by a fierce gust of wind that was sweeping wildly down the valley in which we were alighting. Mr. Spencer still speaks of it as the roughest landing in his long experience. My daughter's fore arm was broken by the first rude impact with the ground; then we charged a 6-foot fence of close-set barbed wire, every strand of which we snapped like mere packthread. Not, however, till my nether garments were almost completely torn off my right leg.

But so far our wild career was in no way retarded, and a few yards farther on we dashed through a hedge and into a half-grown oak, the head of which we carried fairly away, and then at last in the hedge itself the anchor got good hold and the mad race was over.

Then it was we found that in spite of our rough usage we had really alighted in a hospitable land, and among the kindest and most helpful of friends. Our poor, crippled, plunging balloon was soon being held in check by a score of men, while kindly-hearted women, talking in the tongue of southern Wales, came to offer my daughter their assistance and to pin together my tattered garments.

We found we were near the town of Neath, and within half-an-hour were being most hospitably cared for and entertained at the house of Mr. Jones, of Western Moor. In mere duration alone it had been a record voyage in the history of English ballooning—ten hours from start to the finish.

CHAPTER XXII

CONCLUSION

In the course of post I learned that one of our distress messages had been picked up on a mountain side near Pontypridd, and this is the only one to my knowledge which has been recovered. But the tale it tells is remarkable indeed; for it travelled in free air over nearly as many miles as the balloon itself, and thus, assuming the wind constant, must have been approximately as long, *i.e.* about two hours, in falling. There was in this fact the possibility, so it seemed to me, of learning much about the different currents encountered during a balloon voyage.

It was in the following summer after returning from a visit to America, which occupied all the months of spring, that I proposed to attempt to utilise those varying currents which I had so often found holding different courses aloft, to convey a balloon approximately in any required direction. I desired to test whether, say, it might not have been possible for a balloonist by choosing a suitable day and suitable starting point, to take advantage of different upper currents so as to have tacked his balloon from some station along the British lines to within signalling distance of besieged Mafeking.

In this venture I met with the co-operation of Admiral Sir Edmund Fremantle, who not only undertook to act as umpire, but readily consented to share the chances of what was to be his first voyage to the skies. This voyage proved a sensational one. The equipment consisted essentially of a collapsing drum similar to that used in the service, and of such dimensions that hanging in the clear below the car it could be made to transmit Morse code signals at ten or fifteen miles distance. In addition to this we carried detonating signals for summoning the towns and villages which we should approach, and last a gross of post-cards addressed and attached to parachutes which, by slowly descending from points all along our route, would indicate the various currents at our disposal.

The ascent, which was a private one, took place at Newbury at the end of July, and the day proving stormy the departure was postponed till 5 p.m., when there seemed some hope of clearer weather. We were, however, deceived, and twenty minutes after the start became enveloped in a dense thunder-cloud coming up against the wind, and gathering black about us. For some time the storm raged furiously around, the lightning flashing from every quarter, and the sharp hail stinging our faces.

To the country people below our position in the bosom of the thunder-cloud presented an alarming sight, and with ourselves there was the instinctive feeling that we were very much in the wrong place. At any rate, all hope of conducting signalling was at an end, and we therefore lost no time in escaping from our undesirable surroundings, and came to earth in Savernake Forest.

A month later the same attempt was repeated, and with singular success, the balloon, which again started from Newbury, being conducted right over the three military camps on Salisbury Plain, with which we exchanged signals.

This was appropriately followed early in September by an ascent at the garden party of the British Association at Bradford, when Sir Edmund Fremantle once again occupied the spare seat in the car, and took part in wireless telegraphy trials, which on this occasion were carried on across twenty miles. When three or four miles distant in the sky we exploded a mine in the grounds whence we had started, and the messages received in the car terminated only with the life of the balloon, which descended near Sheffield.

I have dealt with aerial travel in these pages mainly in its relation to scientific investigation. That it serves another end in affording charming and exhilarating recreation all who have pursued it as a pastime will testify. Often with myself a sky voyage, undertaken for mere pleasure, has proved a source of truest delight and relaxation for mind and body.

Looking backward one such voyage, in which I was accompanied by Dr. Lachlan, always stands out conspicuously. It was an oppressive summer day in London, close and still too in the suburbs, so still that we left our heavy grapnel behind and floated leisurely away, drifting westward for a few miles, when we suddenly awoke to new sensations as the balloon found wings in a fast northerly upper current, and headed towards the south coast. So away on a delicious sail until the coast was reached, over the very housetops of Hastings Old Town, and until through sheer enjoyment we had lingered aloft almost too long, coming to earth on the bare edge of the high cliff, and not even halting there, for we were anchorless, and the wind now blew stiffly along the shore.

It was thence to the finish that we sped with all the wild excitement which the yachtsman feels in the race or the huntsman when hounds are running; skimming the verge of the cliff and clearing all before us till we found anchorage in an oak tree in romantic Fairlight Glen.

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